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ABSTRACT

The International Environmental Education Programme (IEEP) of UNESCO has developed a series of modules dealing with teacher training in environmental education. This module provides the contents of an experimental teacher training course in environmental education for the in-service training of elementary school teachers and administrators. The units in the document include: (1) the objectives of the module; (2) statements of the need for environmental education and background information on international efforts in environmental education since the Stockholm conference of 1972; (3) basic information about the environment (including descriptions of ecological systems and principles); (4) examples of environmental problems, along with a discussion of the sociocultural factors behind them and some possible solutions; (5) an explanation of several teaching methodologies in environmental education, with a special emphasis on problem solving; (6) experiments and teaching activities; (7) evaluation strategies; and (8) considerations for curriculum development, implementation and management. A bibliography and a glossary of terms are included. (TW)

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Environmental
Educational Series **6**

Environmental Education: Module for In-Service Training of Teachers and Supervisors for Primary Schools

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PREFACE

A series of experimental modules for the pre-service and in-service training of primary-school teachers, secondary-school science and social science teachers in environmental education has been prepared in the context of the Unesco-UNEP International Environmental Education Programme (IEEP) as a follow-up to the Tbilisi Conference Recommendations with respect to the training of teachers in environmental education.

This module focuses on the in-service training of teachers and supervisors in environmental education for primary schools. The main objectives of the module are to (a) foster the acquisition and transfer of knowledge, skills and affective attributes concerning the environment and its problems; and (b) develop competence in the teaching and supervision of the environmental dimension in primary schools. In this context, the module treats (a) historical and philosophical development of environmental education; (b) essential knowledge about the environment and its problems; (c) teaching methodologies, activities and experiments and evaluation in environmental education; and (d) strategies for integration of the environmental dimension into primary school curriculum.

The Module for In-Service Training of Teachers and Supervisors in Environmental Education for Primary Schools has been prepared under Unesco contract by the National Council of Educational Research and Training (NCERT), New Delhi, India (B.D. Atreya, Shri G. Guru, N.H. Jangira and D. Lahiry). In the process of preparation, the first draft of the module was studied for revision and its local adaptation by teacher educators at the Subregional Workshop on Teacher Training in Environmental Education for Asia organized at the National Council of Educational Research and Training, New Delhi, India, 3-16 March 1983, and at the Subregional Workshop on Teacher Training in Environmental Education for the Caribbean organized at the School of Education, University of the West Indies, Mona, Kingston, Jamaica, 18-29 July 1983. Professor Willard J. Jacobson, Teachers College, Columbia University, New York, edited the second draft. Unesco appreciates the efforts of those who have contributed in the preparation of this module.

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UNIT 1

1. INTRODUCTION

This module provides the contents of an experimental teacher-training course in environmental education (EE) for the in-service training of primary-school teachers and supervisors. The module consists of units which follow, more or less, a common pattern of presentation.

The module contents introduce the reader to the objectives in Unit 2 and to the background of international efforts for the promotion of EE since 1972 in Unit 3. The need of having an environmental dimension to education at all levels is also discussed in Unit 3. The knowledge about the environment essential for the in-service training of primary-school teachers and supervisors has been dealt with in Unit 4 in some detail. It is supposed to serve as a core academic content of the in-service training course. This is followed by Unit 5 on environmental problems and their solutions. It is hoped that the previous unit on content would give sufficient background for the appreciation of the nature of environmental problems and for the achievement of the other objectives of this unit. Teaching methodologies in EE with special emphasis on problem-solving approaches at the primary-school level have been elaborated in Unit 6. Experiments and activities to facilitate the teaching and learning about the environment through the primary-school subjects have been discussed in Unit 7. Units 8 and 9 deal with (a) evaluation in EE teaching and (b) strategies for planning, development, implementation, management and evaluation of the environmental dimension of the primary-school curriculum. It is hoped that this module will give sufficient background to primary-school teachers to introduce environment-based teaching in their respective subject areas.

The module is addressed to primary-school teachers and supervisors who may themselves have a minimum of ten years of schooling, not necessarily with science as a subject. The material may be used as a basic text for organizing two to four weeks' orientation courses by the teacher-training agencies.

1.1 Modality of implementation

Two alternative modes of implementation may be considered: (1) to make funds available to States for running courses to implement this module and (2) to infuse the content/approach/methodology of this module into the States' own programmes of in-service training at the primary level. It would, however, not be possible in either case to give any specific implementation requirements because of the differences in school systems and their environment.

In the first modality one may start planning on the basis of the amount of funds made available. A two to four weeks' course may be organized if sufficient funds are available to implement this module. The details of the course content may be drawn up keeping in view the educational background and experience of the course participants who may be teachers, teacher educators or even curriculum developers.

If the budget provision is meagre, one may have to be content with one or two national level workshops, inviting one or two key persons (in-service teacher education personnel) from each State/Union Territory. A suitable course curriculum can then be drafted for an optimum duration of the workshop (say, five to ten days). A day-to-day schedule of activities can then be drawn up. Quite often the expertise developed at the training workshop is not utilized, so a special care is needed to get the right type of trainees deputed for the workshop.

In the case of the second modality the course planners must first gather information about all in-service training programmes at the primary level in the States/Union Territories. The course content for EE may be selected, organized and infused into the existing training courses. The EE content may be drawn into several small units which can be covered in two to five days and are more or less independent of one another. The schedule of activities can then be drawn up keeping in view the course design of the State/s in-service training programme so that this infusion is, as far as possible, very smooth.

In either of the above two cases the trainees must also be oriented towards being aware of the environmental problems of the locality and their solutions within the context of the national-, state- and block-level developmental programmes. The trainee should also be oriented towards the assessment of students' learning in EE in terms of knowledge, attitude, interest, commitment, etc.

UNIT 2

2. THE OBJECTIVES OF THE MODULE

The specific objectives of this module and, through this module, of the in-service training course are:

to increase awareness, sensitivity and consciousness of in-service teachers and supervisors of primary schools about the environment, its problems and their solution and prevention;

to acquaint the in-service teachers and supervisors with the need, importance, goals, objectives and guiding principles of EE;

to acquaint the teachers and supervisors with essential knowledge about the environment and its allied problems;

to acquaint them with fundamental environmental concepts that may permeate primary-school subjects;

to help them realize the totality of the environment as a fundamental base for interdisciplinarity among primary-school subjects;

to familiarize them with the methodologies which are useful for the teaching of environmental dimension of primary-school subjects;

to familiarize them with certain activities and experiments which are essential to and motivating for the learning and teaching of the environmental dimension of the primary-school subjects;

to familiarize them with evaluation techniques and methodologies in EE for guiding the progress of primary-school students as well as the teacher's own effectiveness vis-a-vis the EE objectives.

UNIT 3

3. THE NEED AND BASIS FOR ENVIRONMENTAL EDUCATION IN THE IN-SERVICE TRAINING OF PRIMARY-SCHOOL TEACHERS/SUPERVISORS

3.0 Introduction

This unit deals with the need for giving an environmental dimension to education at all levels. Various factors and activities of man result in environmental degradation. These have been touched upon briefly to focus the attention on the new expectations of society from the educational systems in terms of environmental protection and improvement. Efforts have been made in the unit to elaborate the historical developments in the area of EE. The identified and stated goals, objectives and guiding principles for the planning and development of EE programmes worked out by various international agencies have been discussed. The special efforts of the different organizations at the international level (like Unesco, UNEP) are also mentioned.

Lastly, the need and justification for orientation and training of classroom teachers and supervisors for effective implementation of EE have also been discussed.

The unit aims at enabling the teachers and supervisors to appreciate the need of environmental protection and improvement vis-à-vis education. It will help them to understand the goals, objectives, philosoph- and guiding principles on which the EE programmes are being planned and developed. After going through the unit the teachers and supervisors would be more aware of the international and national efforts for developing EE including the training of personnel and practising teachers.

3.1 Need and Justification for Environmental Education (EE)

Environment and man have been two inseparable entities ever since the appearance of the latter on the scene. They have been interacting, and the sensitive relationship between them was operating harmoniously because the limited needs of our ancestors could be met from the surroundings themselves. The functioning of nature was undisturbed largely because the number of human beings was small and their demands on the environment and its resources were also insignificant. The only damaging actions of man against environment were probably limited to making a fire, hunting and poaching.

Later on, he started settling down and cultivating food rather than wander in search of it. Though this led to development, yet due to man's limited knowledge, the side-effects of poor management of land and other resources were not foreseen. These settlements, besides providing the basic necessities of life, gave enough time to man to think of the ways of extracting more and more from the environment for comfort and luxury. The fast development and progress in the name of prosperity gave man extensive powers to misuse the environment rather than make its judicious use for human betterment.

Interestingly, man in the beginning sought only the knowledge about his environment and was concerned about living with it peacefully but his actions afterwards led to reckless exploitation of nature. In certain cases it seems he has already done permanent and irreparable damage to the environment. The whole spectrum of his damaging activities is seen in the large-scale destruction of forests, loss of fertile soil through erosion, frequent floods, shortage of fuel, energy crises, pollution, extinction of living species, poorly planned industrial and urban development and much more. The list is ever growing. It has resulted in an overall ecological/environmental crisis, wherein not only the environment is being degraded but the very survival of the human species is threatened. It appears that the world dominated by the mind (Noosphere: Noosmind) is fast replacing the naturally evolved world (biosphere).

In some areas human efforts have led to fast development resulting in environmental imbalance while other areas still experience environmental problems on account of underdevelopment. At present it seems that both the overdevelopment due to thoughtless planning and the underdevelopment due to shortage of resources are responsible for environmental deterioration. Man now looks at the environment with greed rather than for his needs. The reckless exploitation of the environment may soon create a point of no return, and we may find ourselves helpless to retrieve the situation. Some environmental situations need immediate remedial measures for preventing the furtherance of environmental problems.

We all must realize our responsibility towards the environment and appreciate the need for its protection and preservation. Let us leave behind a good legacy of a healthy environment for the future generations. The time is ripe for us to review our relationship with the environment and bear in mind that the environment cannot be exploited beyond certain limits. The misconception that the environment can be used to the maximum must be shed because as a result of our damaging actions the environment is losing its recuperating power fast.

One mode of reviewing our relationship with the environment could be to assess how much correct information we have about it. Another could be to analyse our own skills for solving environmental problems. In view of the present environmental crisis the review also involves our concern for saving the environment particularly from the man-made disasters. For example, the studies carried out in the recent past have shown that human activities are interfering with the basic ecological principles like flow of energy and mineral cycling. The shortening of food chains and making nutrient cycles acyclic may be the root cause of the present environmental crisis.

The question now arises: how could we achieve the aims of having better knowledge of the environment, gain appropriate skills to employ the knowledge, and initiate actions leading to judicious use of environment without disturbing the ecological balance? If we are to prepare environment conscious citizens it will be difficult to ignore the role of educational systems which are well known pathways of disseminating knowledge and preparing better individuals. People, the world over, have realized the critical role of education in solving the environmental crisis. Society as a whole has new expectations from the educational system and its role in the amelioration of the present environmental crisis. Education today should have greater relevance to the environmental realities which may strengthen its ethical function. The fulfilment of these expectations will have both short-term and long-term significance for preparing individuals who would keep the environment healthy and safe. Education must enable the citizens to design, devise and plan actions which are in harmony with the environment.

Education of, about and for the environment will definitely help individuals to realize their responsibility, not only towards their fellow beings, but also towards the total environment. The new term 'environmental education' is really not a new concern for the environment as far as learning is concerned. It was practised at all levels of learning especially in informal ones. It has also been pointed out by educationists that it would not be considered another type of education. It is only for renewing the emphasis on environment and the related issues in the educational system as such. In other words, it is also considered a new approach to education with more emphasis on the identification and development of values and classification of concepts, in order to develop problem-solving skills leading to the understanding of the interdependence of man and his biophysical surroundings.

Thus the environment may become a focus of education at all levels. The young learners in the primary school generally learn through observation, which includes actions of others. Children in their surroundings come across large numbers of environmental situations and actions like cleanliness and disposal of wastes. They may develop attitudes and commitments to such situations by watching the actions of their elders. The primary stage is considered to be a sensitive stage for learning and for forming attitudes. It may be easier to develop right attitudes among children rather than change the attitudes among adults. Imparting environmental education to primary-school children thus assumes significance.

3.2 History of EE

Environmental education was practised in ancient times too, though more attention under the term 'nature' was paid to the physical, chemical and biological factors. For example, the Indo-Aryans lived in harmony with nature and enjoyed its beauty. They developed introspective mind for it. Both in the pre-Vedic and the Vedic periods the Aryans sang hymns in deep appreciation of nature. The writings of ancient philosophers namely Hippocrates, Aristotle and many religious preachers are also ecological/environmental in nature. In the present century emphasis has shifted to the social environment, besides the physical, chemical and biological environment, which brings human beings into focus.

Stockholm conference

The first major step in this direction was the conference on 'Human Environment' held at Stockholm in 1972. It gave a renewed plan and emphasis on knowing the totality of the environment keeping in view the environmental damage resulting from the activities of man. It was realized that the total collapse of the environmental system may not be far off if the human onslaught on the environment continued at its present pace. Man has already developed strained relationships with nature and it is becoming clear that, unless human beings mend their ways, improve their actions and adopt a sympathetic and respectful attitude towards the environment, humanity's doomsday is not far off. The conference drew the attention of societies to studying man vis-à-vis the physical, biological and social environments. It also viewed EE as a new emerging concept since the 1960s. The Stockholm declaration 'to defend and improve the environment for present and future generations' has become an important goal for mankind and it indicates the seriousness and sensitivity with which the environmental issues should be viewed.

The conference recommended the development of EE as one of the most powerful instruments in an all-out attack on the world's environmental crisis. Since then it has provided a lead to national and international agencies for developing and implementing programmes for EE.

The Stockholm conference, attended by 113 nations, United Nations agencies and non-governmental organizations, made several recommendations aiming at a new integrated plan of action for improving the overall relationship of man with the environment. The recommendations covered the following three broad areas of concern:

Environmental assessment

Environmental management

Supporting measures for the above two.

Education, training and enhancing or dissemination of information were identified to promote above areas of concern.

The conference as a part of its action plan recommended:

the establishment of a United Nations Environment Programme (UNEP);

launching of environment fund;

Human Environment Declaration for adoption by the United Nations and national governments on the pattern of the Human Rights Declaration;

the celebration of 5 June as World Environment Day every year;

the establishment of a global programme with the co-operative efforts of all United Nations bodies for promoting EE.

The recommendation (96) of the Stockholm conference stated: '... that the Secretary-General, the organizations of the United Nations system, especially Unesco, and the other international agencies concerned, should, after consultation and agreement, take the necessary steps to establish an international programme in environmental education, interdisciplinary in approach, in-school and out-of-school, encompassing all levels of education and directed towards the general public, in particular the ordinary citizen ... with a view to educating him as to the simple steps he might take, within his means, to manage and control his environment'.

In 1975, Unesco and the United Nations Environment Programme (UNEP) launched, in response to Recommendation 96 (above), the International Environmental Education Programme (IEEP), which was designed to promote reflection and action, as well as international co-operation in this field. Its principal long-term objectives were: (i) facilitating the co-ordination, planning and programming of activities essential to the development of an international programme in EE; (ii) promoting the international exchange of ideas and information pertaining to EE; (iii) co-ordinating research to understand better the various phenomena involved in environmental teaching and learning; (iv) designing and evaluating new methods, curricula, materials and programmes (both in-school and out-of-school; youth and adult) in EE; (v) training and retraining personnel to adequately staff EE programmes; and (vi) providing advisory services to Member States in EE.

The action of the International EE Programme in the last nine years was conducted in three phases, centring successively on: (1) the development of a general awareness of the necessity of EE; (2) the development of concepts and methodological approaches in this field; (3) efforts for incorporating an environmental dimension into the educational process of Unesco Member States.

During its first phase (1975-1977), the main action of the IEEP was devoted to the development of general awareness of the necessity of EE and the identification of EE needs and priorities of Member States. The concern for problems of the environment and, more particularly, for an education pertaining to these problems - which, before 1975, was a matter of interest for particular groups within a limited number of industrialized countries - finds an echo in all regions of the world, as testified by the efforts and experiences made in this field by numerous countries with the co-operation of the IEEP (131 Member States - about 82 per cent of Unesco membership - have been involved in various activities of the IEEP: 30 in Africa, 21 in Asia and the Pacific, 16 among the Arab States, 32 in Latin America and 32 in Europe and North America).

Among the first phase actions of the IEEP contributing most to the development of a global EE awareness was the series of international and regional meetings which led to the Intergovernmental Conference on Environmental Education (Tbilisi, USSR, 1977)- In this connection, the International Workshop of Belgrade (1975) was particularly important: its recommendations and guidelines provided a preliminary frame of reference. The regional meetings of experts which followed, organized in Africa, the Arab States, Asia, Europe and North America, as well as an international survey of EE needs and priorities of Member States, contributed the next step by reviewing the Belgrade recommendations in the light of the needs and priorities of each of the different regions. The Tbilisi conference culminated the first phase of the IEEP, laying the basis for the development of EE at the international level as well as strategies for the advancement of EE at the national level and the promotion of international co-operation.

A policy of regular, periodical information has also contributed considerably to international awareness of EE, notably through the International EE Programme's international newsletter Connect, which appears in five languages and is distributed to about 12,000 individuals and institutions of the five world regions, actively involved in the promotion and development of environmental education and training.

The development of a general awareness has continued to be a principal concern of all IEEP activities throughout the years.

The second phase of the IEEP (1978-1980) has been primarily devoted to the conceptual and methodological development of EE with the view to providing Member States with useful references for the incorporation of an environmental dimension into general educational practice.

In this regard, the IEEP has initiated a series of studies and activities concerning different pedagogical aspects of EE, launched a series of pilot projects in different countries of various regions of the world and initiated a series of training workshops and seminars at the national, subregional and international levels.

Similarly, the IEEP has stressed the interdisciplinary approach taken by EE so as to effectively contribute to the solution and prevention of environmental problems in their multiple aspects. In this connection the IEEP supported an international seminar on interdisciplinary EE at the primary and secondary levels (Budapest, Hungary, November 1980). Publications of the IEEP, including its newsletter and books, such as Environmental Education in the Light of the Tbilisi Conference and Trends in EE, have helped to disseminate widely these conceptual and methodological approaches and orientations.

In order to keep the international community acquainted with EE activities and developments, the IEEP has continued to diffuse the newsletter Connect and has been steadily building up a computerised information system (CDS/ISIS) which is compatible with that of many other agencies and institutions. The data base presently contains information on 900 institutions and 300 EE projects, published in regularly updated directories.

During the third phase of the IEEP (1981-1983), emphasis has been placed on the development of content, methods and materials for EE practices and training activities; experimental and pilot projects have been intensified, with a view to facilitating Member States' efforts concerning practical incorporation of EE into school and out-of-school education. The contribution of the IEEP to the latter has, more particularly, involved three areas: the development of content, methods and materials for EE, the training of teachers and the promotion of international co-operation with and among Member States and other bodies in the field of EE.

As for educational contents, methods and materials relating to EE, the IIEP has developed a series of studies, research activities and projects leading to the preparation of methodological guides concerning approaches for the incorporation of an environmental dimension into educational practice (i.e. interdisciplinary approaches in EE; problem-solving approaches in EE; environmental value education; evaluation methodologies for EE; modular approaches for EE; integration of an environmental dimension into social studies at school; integration of an environmental dimension into arts education; strategies for the training of teachers in EE; suggestions for developing national strategies for EE, etc.). With respect to the development of EE content, the IIEP has produced sourcebooks for teachers on formal and non-formal EE, a multilingual glossary of EE terms and an annotated bibliography. Complementary to these core elements, the IEEP has also prepared a series of educational modules dealing with major environmental problems (conservation of natural resources, pollution, desertification, human settlements, health and nutrition) and aiding teachers to conduct practical EE activities at primary and secondary-school levels. Similarly, a series of modules designed to serve as teaching units for the pre- and in-service training of primary and secondary-school teachers and supervisors in the areas of natural and social sciences has been developed. Adaptation of the educational and teacher-training modules to local conditions has been initiated.

In connection with the latter, mention should be made of the significant role played by the 23 pilot projects undertaken by the IEEP, which have contributed to the incorporation of EE into national educational processes by facilitating the training of teachers and educators by developing educational and informational materials suitable to local environmental situations and conditions, and by sensitizing the population in general.

With respect to teacher training in EE, the IEEP has organized 11 regional and subregional training workshops in Africa, the Arab States, Asia, Europe and Latin America and the Caribbean for such educational personnel as curriculum developers, teacher trainers and administrators, as well as 35 national training workshops in all regions. Similarly, an international training course was organized for participants from developing countries in September 1982 in Czechoslovakia.

As for international co-operation, the IEEP has significantly aided efforts of a number of countries concerning the incorporation of an environmental dimension into their educational systems. As a result of its various activities in the areas of information, research and experimentation, as well as training, and as an outcome of specific technical missions undertaken by the IEEP staff, a number of countries have officially introduced EE into their educational plans, policies and reforms and have developed complementary legislation or appropriate institutional arrangements. In many cases these countries have established ministerial or inter-institutional committees with responsibility for the development of EE in various levels or modalities of the education system. (Among the countries concerned are: Australia, Colombia, Costa Rica, France, Federal Republic of Germany, Guatemala, Indonesia, Upper Volta, Ukrainian Soviet Socialist Republic, United States of America, Union of Soviet Socialist Republics, Venezuela, and others.)

Through its activities, the IEEP has directly involved 133 countries from all regions of the world, more than 250,000 pupils in primary and secondary schools, about 10,000 teachers, educators and educational administrators, and has contributed to environmentally sensitizing some 1,500,000 persons. From another point of view, more than 1,700 primary and secondary schools as well as some 130 training schools and research centres have also been involved.

3.3 Philosophy, goals, general objectives and guiding principles of EE

Philosophy

Education at present does not prepare individuals for better management of their lives vis-à-vis the environment in which they live. Moreover, the scientific knowledge gained by man has helped him to a great extent by providing material comforts, increasing life expectancy, controlling diseases, developing new economic varieties (high yielding, fast growing and disease resistant) of plants and animals. But unfortunately in the process many environmental problems have crept in as by-products, knowingly or unknowingly. Now it is felt that all the environmental problems may not be solved in spite of the availability of advanced scientific and technological knowledge. As a note of caution Buzzati-Travesso (1977) has rightly pointed out that the problems at hand are far greater than our ability of understanding and solving them with knowledge at hand.

EE can help in preparing individuals who are more aware of their environment and its problems and are able to understand man-environment relationships from a more human point of view and act wisely while making decisions. This would require bringing education closer to the realities and relevance to life which would further help in improving man's contact with the physical and social environment. Moreover in adding an environmental dimension to general education would help in restoring it ethical function. Aldo Leopold (1933) in his writings on conservation ethics mentioned that with regard to environment, 'Yet there is no ethics dealing with man's relationship to land and to the non-human animals and plants which grow upon it. The land relation is strictly economic entailing privileges but not obligation'. In the wider context this is perhaps true even today.

This calls for new ethics in educational systems. The educators, philosophers, scientists and environmentalists today still feel that in spite of the best intentions and seriousness it will not bring expected results till a new ethical order in environmental values is identified and integrated with all our activities including science, technology, politics, development and education. The past prescriptions by religious preachers and thinkers to keep the environment clean and healthy do not work in the present cultural settings because of fast cultural changes.

The major share of the blame for the present environmental crisis goes to man. Our activities leading to environmental degradation clearly indicate no change in our attitudes, thinking and ethics towards environment. Aurelio Peccei (1975) has rightly mentioned that 'the bulk of mankind now feels estranged from what it has created and frustrated by unaccustomed realities which escape its control and comprehension. The more this situation develops, the greater the danger for it to end in anger or in collapse'. The Tbilisi conference also called for a positive and enriching influence of environmental ethics and values through the development of EE.

In a true sense a more sympathetic and serious view of the intricacies of human relationships with the environment and vice versa would need an attitudinal change, new commitments, respectable behaviour leading to a new ethical order. The new ethics, as far as environment is concerned, expects man to be only a part of the total environment and not the whole. It would probably provide a new philosophical basis for contemporary educational renewal.

Goals and objectives

The need for having well-established EE programmes focusing on humanity's relationship with the environment has been discussed earlier. If we see the efforts made in the past decade or so, it becomes very clear that any educational programme designed with an environmental dimension should be based on the identified and agreed upon aims and objectives keeping in view the holistic nature of the environment.

The first serious attempt in this direction was made by the Belgrade Workshop (1975). It identified, in its charter, the major goals and general objectives of providing education about the environment and the related issues. The workshop elaborated the expectations of the society from EE as: 'to develop a world population that is aware of and concerned about the environment and its associated problems and which has the knowledge, skills, attitudes, motivations and commitment to work individually and collectively towards solution of current problems and prevention of new ones'.

The Intergovernmental Conference on EE organized by Unesco in collaboration with UNEP in Tbilisi, USSR, in October 1977 endorsed the following goals, objectives and guiding principles for EE.

1. The goals of EE are:

   (a) to foster clear awareness of, and concern about, economic, social, political and ecological interdependence in urban and rural areas;

   (b) to provide every person with opportunities to acquire the knowledge, values, attitudes, commitment and skills needed to protect and improve the environment;

   (c) to create new patterns of behaviour of individuals, groups and society as a whole towards the environment;

2. The categories of EE objectives:

   Awareness: to help social groups and individuals acquire an awareness of and sensitivity to the total environment and its allied problems.

   Knowledge: to help social groups and individuals acquire a set of values and feelings of concern for the environment, and the motivation for actively participating in environmental improvement and protection.

   Skills: to help social groups and individuals acquire the skills for identifying and solving environmental problems.

   Participation: to provide social groups and individuals with an opportunity to be actively involved at all levels in working toward resolution of environmental problems.

3. Some guiding principles for EE:

   EE should:

   consider the environment in its totality - natural and built, technological and social (economic, political, technological, cultural-historical, moral, aesthetic);

   be a continuous lifelong process, beginning at the pre-school level and continuing through all formal and non-formal stages;

   be interdisciplinary in its approach, drawing on the specific content of each discipline in making possible a holistic and balanced perspective;

examine major environmental issues from local, national, regional and international points of view so that students receive insights into environmental conditions in other geographical areas;

focus on current and potential environmental situations, while taking into account the historical perspective;

promote the value and necessity of local, national and international co-operation in the prevention and solution of environmental problems;

explicitly consider environmental aspects in plans for development and growth;

enable learners to have a role in planning their learning experiences and provide an opportunity for making decisions and accepting their consequences;

relate environmental sensitivity, knowledge, problem-solving skills and values clarification to every age, but with special emphasis on environmental sensitivity to the learner's own community in early years;

help learners discover the symptoms and real causes of environmental problems;

emphasize the complexity of environmental problems and thus the need to develop critical thinking and problem-solving skills;

utilize diverse learning environments and a broad array of educational approaches to teaching/learning about and from the environment with due stress on practical activities and first-hand experience.

3.4 In-service training of teachers/supervisors

The discussion in the earlier sub-units is a pointer to the fact that knowledge about environment and its problems is a necessity and that it is also becoming a reality not only in the educational systems but also in our lives. Once it is established, the next important step in the process is to design and develop EE programmes based on identified and stated goals and objectives for all levels of education, formal and non-formal. The school plays a major role in the formal system of education and it is expected to play a critical and central role in the totality of EE thrust. Further within the school a teacher still remains a central figure. Children look upon their teachers as the embodiment of knowledge and learning. Teachers lacking in desired academic background, orientation and training may find it difficult to impart instruction with proper environmental focus. The teaching may remain of an academic interest only. Also, teacher educators and supervisors may find it difficult to implement environmental education of which they themselves have had no experience because of differences of aims, objectives, philosophy and approach from the traditional teaching of disciplines.

The area of training teachers, both pre-service and in-service, has also been mentioned by the Tbilisi conference in its recommendations as a top priority for effective implementation and further development of EE programmes. While recommending the enrichment of pre-service curricula with environmental sciences and EE, it also called upon the Member States to adopt certain measures to provide in-service training to all teachers who need it. It further recommended that the implementation and development of in-service training in EE be made in close co-operation with professional organizations of teachers both at the international and national levels. The conference also advised Unesco to promote the dissemination of ideas and to prepare programmes and instructional materials relevant to the strengthening of in-service training in EE.

Though the curricula, especially in schools the world over have been given an environmental dimension, their actual implementation in the classroom is still far from satisfactory. The biggest factor is the inadequacy of trained teachers and personnel. The nature, extent and scope of EE call for a large-scale programme to expose teachers to educational opportunities and research methodologies that can be used in designing and developing methods and instruments so that they can fulfil more effectively the objectives of EE. The emphasis for primary-school teachers and supervisors should be on updating their knowledge, skills and commitments from time to time.

The regional workshops held in different parts of the world have also emphasized the promotion of EE by enriching the present in-service training programmes and also by developing the new ones in this direction. The training of those having some pre-service experiences in EE should also form a necessary part of in-service training efforts.

The training should enable the teachers to equip themselves with basic competencies required for effective dissemination of EE. The in-service training programmes, thus, should assess the needs of practising teachers with respect to EE. The designing of each programme should be based on the following:

academic background in terms of knowledge and skills;

analysis of the curriculum, with respect to environmental components, in the existing pre-service training institutions which are the major feeders to the school systems;

analysis of the school curriculum, from an environmental viewpoint;

the extent of involvement of teachers in designing and developing an environment-based curriculum;

assessment of awareness and knowledge of teachers about the local environmental problems;

assessment of the present role of teachers in the classroom *vis-à-vis* the expected role of achieving an effective dissemination of environmental instruction;

assessment of competencies already acquired by teachers for the teaching of disciplines;

identification of basic competencies required by teachers for imparting EE;

identification of the core knowledge and skills and teaching methodologies required for EE which teachers can employ irrespective of their place of work;

identification of the expectations after the teacher/supervisor has undergone training.

The training programme should also envisage the development of the following among teachers and supervisors:

(i) positive attitudes towards the environment as a result of EE;

(ii) commitments towards the environment which would help them to teach the environmental issues more convincingly;

(iii) awareness of instructional materials dealing with both environment and EE, especially in their own languages;

(iv) urge for gaining more knowledge and skills for a better understanding of the intricacies of the environment's relationship with mankind;

(v) confidence to express views on issues in right perspective irrespective of any bias.

The training programme should be able to motivate the teacher, arouse his curiosity and develop in him a sympathetic attitude and human concern for the cause of the environment. The essential knowledge which a teacher should possess for effective teaching of environmental dimension is covered in the next unit.

UNIT 4

4. ESSENTIAL KNOWLEDGE ABOUT THE ENVIRONMENT FOR THE IN-SERVICE TRAINING OF PRIMARY SCHOOL TEACHERS AND SUPERVISORS

4.0 Introduction

This unit attempts to present a résumé of the main factors and interrelations that regulate the natural and the socio-cultural (man-made) environments. The content in this unit has been divided into three sub-units, namely, (i) Environment - its origin and nature, (ii) Pathways of matter and flow of energy, (iii) Ecological system.

The first sub-unit deals with the basic features of the environment and the fundamental principles and concepts that govern the evolution, sustenance and changes in both the natural and the socio-cultural (man-made) environments. The themes of matter and energy, interaction and change, as fundamental factors of the environment, permeate through the content.

The second sub-unit deals with the pathways of matter and the flow of enerby through the living world. The content highlights the importance, significance and the path of interchange of materials between the living and the non-living worlds as a regular and necessary phenomenon for the balance of nature. The cycles of some important materials like carbon, oxygen, nitrogen, water, etc., have been described to provide basic ideas for understanding the balance in the environment. The transfer of energy and matter through various food chains and food webs and the role of man in each of them have also been described.

The third sub-unit discusses the ecosystem as a tangible unit of the environment. The impact of man on the ecological relationships is discussed. The concepts and implications of physical (biotic) factors and the adaptation by different organic forms are described briefly. The concepts of biotic factors such as species, population, and the biotic community, with particular attention to man and his interferences in the system, have been highlighted.

It is hoped that this unit would provide the basic knowledge and understanding essential to appreciate the problems of the environment discussed in the next unit.

4.1 Environment - its origin and nature

4.1.1 What is the environment?

The word 'environment' commonly means 'the surrounding'. But in the context of the living beings it means much more. We observe that every organism lives in the midst of various living and non-living objects, happenings and influences (both natural and man-made) the aggregate of which forms its environment. All organisms - plants and animals including man - depend upon their environment for their life and its continuance. The organism also tends to change and effect its surroundings in many ways, which in turn may affect the organism itself. Thus, the activities of organism, to a large extent, determine its own environment.

A careful observation would reveal that a close interaction between the organism and the environment is essential to satisfy the bare necessities of the organism. Some of the gross dependencies, such as, shelter, temperature, oxygen, water, food mate are quite apparent. In our study of the environment, the living world will be the main theme keeping man as the central figure. The interaction and relation between the various factors are so smooth and often so slow that we are not particularly aware of the complexity of those interrelations until something goes wrong.

We would also observe that no organism can live without an environment. Man is no exception. His dependence on the environment is even more than other organisms'. For, man is more than a mere biological being. A civilized man requires more things for his comfort and safety than any other organism. He has developed a new kind of environment - the social and cultural environment - in addition to the natural environment. This man-made environment ultimately depends and draws on the natural environment.

As a beginning of the study of our environment, let us look at our surrounding and make a list of the objects and happenings in our environment and then try to find out how they are related to us and to each other. The list will vary, depending not only on the subjectivity of observation of the persons making the list but also on where and when they are making the list. A reasonable list is likely to include: (i) individual men variously related to one another as members of the families, friends, colleagues, teachers and students, (ii) man-made objects, like clothing, furniture, utensils, decorative materials and tools, (iii) plants and animals, such as domestic animals, birds, insects, garden plants and weeds, (iv) natural objects like the sun, the moon, rivers, mountains, and (v) many happenings like the rising and the setting of the sun and the moon, rain, change of the weather.

We would note that the individual and the local environments are not isolated; they are only a part of a larger system - the country or a geographical area. In fact, we would find that the environment is determined not only by the objects and events on this planet earth but also those of the sun, the moon and other objects in the universe. However, it is not very clear how the distant stars and planets influence our environment.

Obviously, the list of the various objects and events will be an infinite inventory. Therefore, to facilitate the study of the human environment, it is convenient to classify the environmental components into two broad categories: (i) Natural environment. (ii) Socio-cultural or man-made environment. Both natural and socio-cultural environments again have non-living and living components in them. These components are not mutually exclusive; they closely interact with one another. The nature of the interactions and the complex relations between the various factors within and among the three components have been briefly discussed in appropriate contexts.

4.1.2 Natural environment

The factors affecting the natural environment can be broadly classified into (i) physical or abiotic factors, and (ii) the biological or biotic factors.

Physical or abiotic environment

The most important physical factors are the climatic factors and the edaphic (related to the soil) factors. The climatic factors include temperature, humidity, rain, snowfall, wind, etc. The edaphic factors comprise the soil and the substratum.

The earth is the third planet in the solar system with a satellite - the moon. It receives much of its energy from the sun. The rotation of the earth about its own axis inclined at an angle of 66½° to the plane of its orbit (and not at a right angle) causes the variation in the duration of day and night at different latitudes. The revolution of the earth round the sun in an elliptical orbit leads to the change of seasons (Fig. 1). These two motions of the earth also lead to the formation of different temperature **zones** - torrid, temperate and polar, grossly following the increase of latitudes (Figs. 2, 3). Again, owing to the gravitational force the density of air at higher altitudes gradually decreases and air loses the capacity of retaining the heat received from the sun. The difference in the heat-retaining capacity of water and land also contributes determing the climatic conditions in different parts of the earth. The unequal heating of the land mass and the ocean of different parts of the earth (Fig. 4) leads to the formation of different pressure zones, both vertical and horizontal. This gives rise to air (Fig. 5) and ocean currents. These factors affect the evaporation of water from the earth's surface, the formation of clouds and their movements, rain and snow, storm and cyclones, etc. The tides are formed by the gravitational force of the moon and the sun on the oceans. All these physical changes in the nature have powerful influence in determining the nature of the environment. The physiographic factors like the mountains, steepness of the slopes, oceans, seas and lakes also influence the climate. The soil factors like the presence and absence of the top soil, composition of the soil, its organic and inorganic content, the soil pH, and the moisture-retaining capacity of the soil are of great importance in determining vegetation, animal life as well as the habits and habitations of the human population.

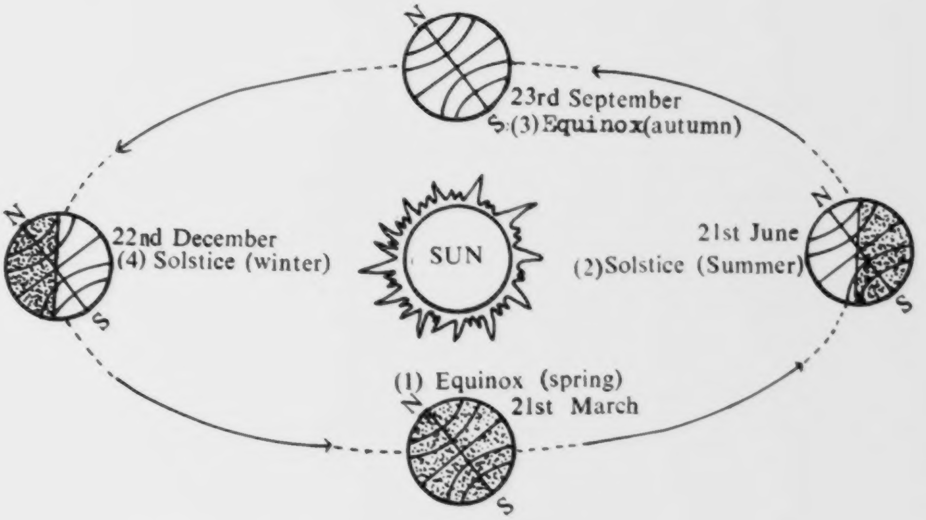


Fig. 1 Solstices and equinoxes

The seasons are primarily due to the tilted axis of the earth keeping a constant orientation in space as the earth revolves round the sun.

Some regions of the earth, such as those near the poles, or at the high mountains, or the deserts are hardly populated because of intolerable temperature, meagre vegetation and lack of agricultural resources. The food, clothing,

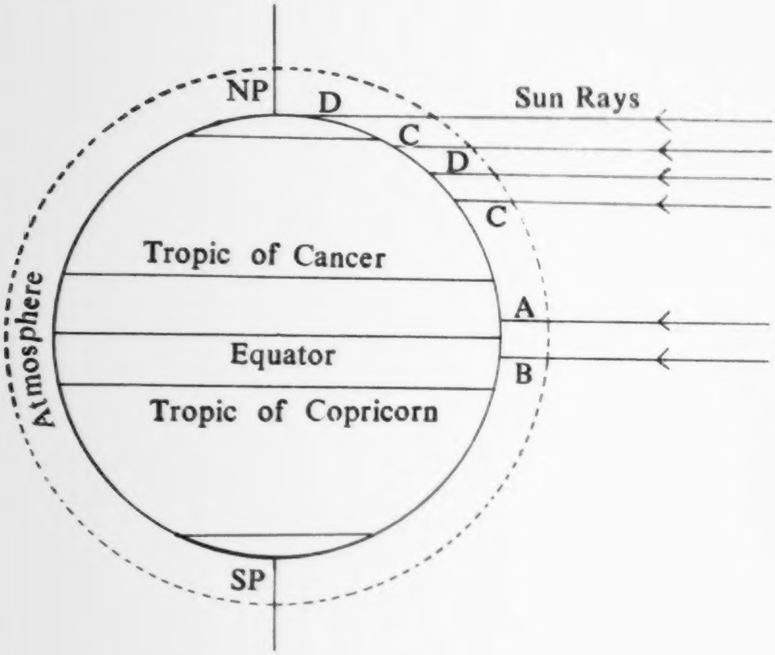

NP
D
Sun Rays
C
D
C
Tropic of Cancer
A
Equator
B
Tropic of Copricorn
Atmosphere
SP

Fig. 2 Effect of the inclination of the sun's rays.

The oblique rays deliver less energy on the earth's surface than the vertical rays because their energy is spread over a large area.

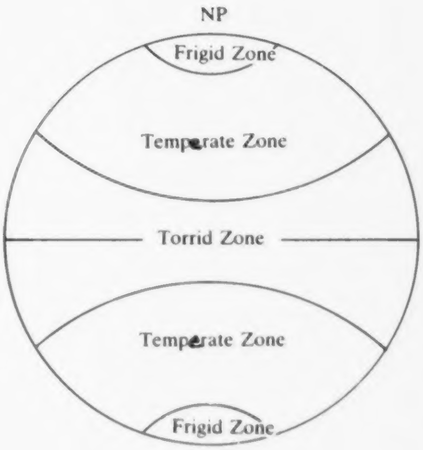
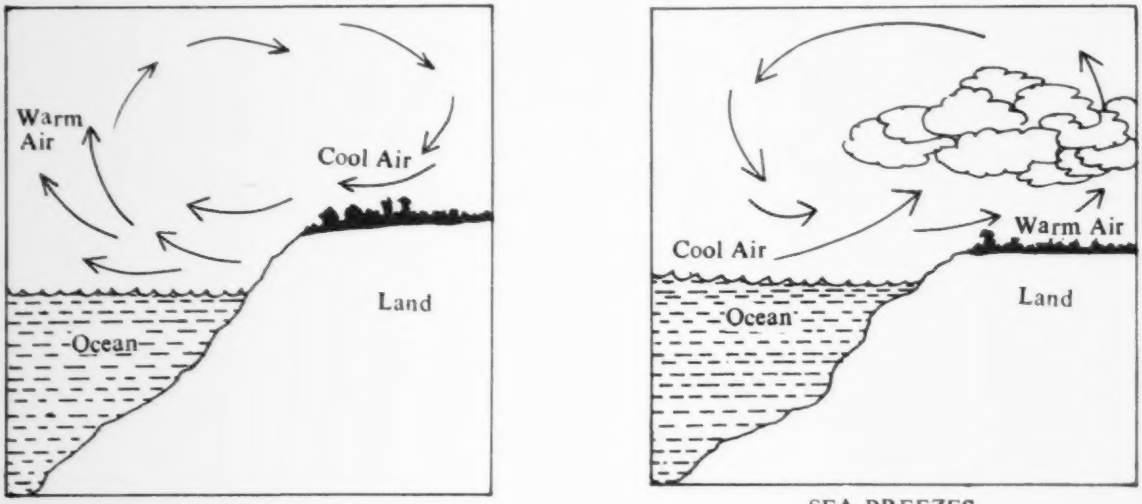

NP
Frigid Zone
Temperate Zone
Torrid Zone
Temperate Zone
Frigid Zone

Fig. 3 Temperature zones.


Warm Air
Cool Air
Ocean
Land
Cool Air
Warm Air
Ocean
Land

LAND BREEZES

SEA BREEZES

Fig. 4 Sea and land breezes.

Sea breeze blows from the sea to land during the day and land breeze from land to sea at night.

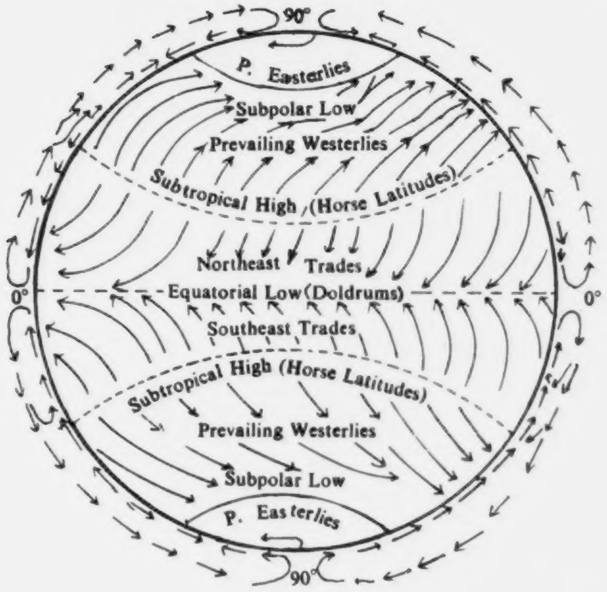

90°
P. Easterlies
Subpolar Low
Prevailing Westerlies
Subtropical High (Horse Latitudes)
Northeast Trades
0°
Equatorial Low (Doldrums)
0°
Southeast Trades
Subtropical High (Horse Latitudes)
Prevailing Westerlies
Subpolar Low
P. Easterlies
90°

Fig. 5. Pressure belts and the prevailing winds.

Winds blow outward from high pressure areas over the tropics and poles to low pressure areas in temperate and equatorial latitudes.

building materials and architecture and elements of living styles vary greatly among populations living under different climatic conditions.

Biological or biotic environment

The biotic environment comprises the living beings - plants and animals, including man. We depend on plants for all kinds of food, medicines, timber and innumerable forest products. We are also dependent on the plants for the sustenance of domestic animals. In fact, all animals are dependent on plants for their survival. Plants also help to maintain the oxygen - carbon dioxide balance of the atmosphere. They also play a very important role in retaining moisture in the soil and binding the valuable top soil, thereby preventing soil erosion and floods.

We are also dependent on many animals for various types of food (say, milk, honey, meat, fish and egg) and other essential items of our daily life (wool, leather and silk), and for transport and agricultural purposes. Some insects and other animals help in pollination, which is so essential for plant reproduction. Animals also help to retain the carbon dioxide balance of the air. A large number of insects and other animals are harmful to man. Some destroy his crop and stored grains. Some are pests on the cultivated plants. Many animals are parasites on man and on his domestic animals. Some of them cause disease and death. Some animals act as vectors and carriers of diseases.

A large number of micro-organisms are harmful to man. Many of them cause diseases like cholera, typhoid, tuberculosis and malaria. Many diseases such as measles, chickenpox are also caused by viruses. Some micro-organisms are useful to man. For example, some yeasts and bacteria help in obtaining curds and alcohol. Some of the micro-organisms also help in decomposing the dead bodies of plants and animals and thus in releasing the various substances required for the use of further growing organic life.

4.1.3 Socio-cultural environment

The socio-cultural environment consists of everything around us, which is developed by man through his tools, skills and social institutions. It has two components - living and non-living.

The man-made environment includes buildings, roads, bridges, cities and villages, irrigation canals, factories, transport and croplands.

The socio-cultural environment comprises a complicated society and social activities originating from culture. All aspects of culture are part of the man-made environment. A society is a closely integrated group of organisms of some species held together by mutual dependence and exhibiting division of labour. Human society is a highly structured organization normally furnishing protection, continuity, security and identity. The integrated structure of human society has grown out of learned behaviour (and not instinct) in the form of traditions, values, morals, customs, norms, mores and folkways. These are transmitted to the progeny through socialization and other forms of cultural communication and not by genetic inheritance. The acquired behaviour patterns, in the long run, get established and take the shape of social institutions, such as family, marriage, kinship, religion, education, economy and polity.

Family, marriage and kinship.

The family is a unit of a community, consisting of individuals having a bond of kinship arising out of marriage. Marriage is related with child-bearing and child rearing and therefore, to population growth and status of health of the population. The system and norm of marriage may vary from community to community. The size composition and traditions of a family also differ. The role of and the state of relationship between the members of a family also affect their environment and behaviour.

Religion

Religion comprises a set of beliefs concerning the cause, nature and purpose of the universe especially when it is considered to be the creation of some superhuman agency or agencies. Religion usually involves devotional and ritual observances and often has a moral code for the conduct of human affairs. It also includes institutionalized beliefs and practices generally accepted by a number of persons and sects. It is a very ancient force determining the social attitudes and values. Quite often religion has influenced the people to live in harmony with the environment.

Education

Education, taken in its broadest sense, is the strongest means of transmission of cultural heredity. In modern societies, it has become a highly organized and planned activity for transferring knowledge and skill from one generation to the other. It has evolved into a well-structured system for achieving social goals. Education, therefore, not only influences attitudes and values but also acts as a powerful instrument of social progress. Education then, is a powerful tool for modifying the environment.

Economy

The word 'economy' would literally mean 'management of the household', but actually this important social institution relates to the production, distribution and use of commodities, resources, income and wealth.

Biologically, man is not a producer; but culturally, he is. He, through his tools, skills and technology, has developed his means of production - agriculture and industry. In modern societies, economy is quite a complex and basic social institution comprising planning and management, profit and consumption. It also includes financial and banking operations at national and international levels. So every social activity in the modern civilization is guided by economic considerations, although the ownership patterns of the means of production and distribution vary from country to country.

Polity

Polity relates to the evolution and structure of the government and the State and their activities like law-making and law enforcing within a particular jurisdiction. The polity of a society reflects its collective decisions. The political systems differ from country to country according to the different stages of societal development.

History

A society is also shaped by its history, that is, by the events, achievements and experiences of the past, in regard to the institutions and activities mentioned above. History is not a dead inventory of the past events but a strong factor determining the norms, emotions and attitudes of the present and of the future to a great extent.

The study of history is important in understanding the culture. The evidences of the achievements and activities of the past are the archaeological objects which form the rich human heritage.

Art and aesthetics

Man has a unique attribute - the aesthetic sense or the sense of beauty. This has given rise to another dimension of cultural activity - art - through which man seeks to get mental satisfaction and relief. Drawing, painting, dance, music and sculpture are some of the main forms of art. Drawing, painting and dance are prehistoric in origin; poetry, drama and innumerable other forms have evolved gradually as the means of expression of complex thought. The creation and appreciation of art have been one of biggest enjoyments of individuals and groups.

With the gradual increase of his power to change his environment, man has also tried to modify his natural environment. He has tried to make the environmental setting in keeping with his aesthetic taste and sense of beauty.

Entertaining and recreation

Man's cultural setting has also an important place for various forms of entertainment and recreation apart from art. Different types of sports and games and festivals are important components of his environment and activity.

4.1.4 Key concepts that determine the environment

To have a comprehensive understanding of our environment (with so many variables and complex relationships) we have to look for some fundamental concepts, natural laws and principles that encompass a wide range of things and phenomena and determine the origin, nature and characteristics of the environment as also of life. This would enable us to discern a common pattern based on which any particular setting can be understood.

Matter and energy

All objects and occurrences in the universe that we can perceive with our senses are the manifestation of matter and energy, interaction and change. They are the key factors of all that exist or happens in life or in the environment. The stars and the planets, rocks and rivers, plants and animals and the man-made objects that we can see, taste, smell and touch are all matter. Matter has mass and volume. It can exist in three different states - solid, liquid and gaseous. The state of any form of matter, say, water, iron or camphor can usually be changed; but, under ordinary conditions, matter cannot be created from nothing.

The light, heat and sound emitted by any object is energy. Our senses of sight and hearing are dependent on the energy of light and sound; we can feel heat. All happenings and activities - the falling of the rain, the blowing of the breeze, the beating of the heart, the flying of the birds, the running of a car or a cart - involve energy. Energy is not involved in an activity only; a mere possibility or potentiality of doing some work or some activity also involves energy. One form of energy can be transformed into another. Light energy can be converted into chemical or electrical energy or to heat and vice versa. But energy cannot be created from nothing.

In nature, matter and energy exist in an integrated form and it is difficult to isolate them. Matter and energy are interconvertible. Energy can be released by splitting matter as in the explosion of an atom bomb. Yet, the sensory distinction between matter and energy still remains a convenient basis for the study of nature and universe and are two key concepts needed to understand the environment.

Matter and materials

One universal feature of all matter in nature including living things and man-made objects is that they are composed of naturally occurring building blocks called the elements. Two or more of the elements may combine to form substances known as compounds having properties entirely different from their constituent elements.

For compounds to be formed, altered or broken down, a particular type of interaction called a chemical reaction, must take place between the atoms or molecules concerned. A particular chemical reaction can take place under certain conditions. A chemical reaction is also an activity and, therefore, involves energy. The reaction by which a compound is formed from its constituent atoms is called chemical synthesis.

Some substances and materials occur as mixtures of two or more elements and/or compounds. In mixtures the constituent atoms and molecules retain their identity without undergoing any chemical change. Air is a mixture of nitrogen, oxygen, carbon dioxide and many other gases.

All the 92 naturally occurring elements are not evenly distributed throughout the universe. The most common element in the universe is hydrogen; but 98 per cent of the earth's crust is formed by only eight elements, namely, oxygen, silicon, aluminium, iron, calcium, sodium, potassium and magnesium. The remaining 84 elements constitute only about 2 per cent of the earth's crust.

Interaction and change

A fundamental feature or phenomenon observed universally in nature is that the components of matter (materials) and the different forms of energy are always in a state of flux and are not absolutely stable. They continuously interact among themselves to produce changes. The product of these changes induce further changes as a continuous process. The universe, including the living world and its environment, owes its origin, nature and continuance to the continuous process of interactions and changes. Some of the interactions are quite apparent.

Some of the changes also are quite familiar to us. For example, changes in the position of living or non-living objects, changes in the stages of life of an individual plant or an animal including ourselves, changes of day and night, seasons and weather. Minor geographical changes, such as the changes in the course of a river, the changes in the landscape by erosion, sedimentation and deforestation are also observable in one's lifetime. All chemical reactions also lead to changes.

4.1.5 Organism and environment as products of evolution

There are evidences that the whole universe, stars and planets and their conditions have undergone gross changes or evolution covering a long period of time. It is considered established fact that the present solar system, including the earth, originated as a product of this continuing process of cosmic evolution or the change of the universe (universal evolution).

The earth, having perhaps been originated from condensation of extremely hot gases or a mass of molten materials, continued to change or evolve. When conditions became suitable, life originated on the earth as a product of the universal change. Since the inception of life the conditions of the earth which made the origin of life possible have changed and possibly no new life is being spontaneously formed now. New life now arises from pre-existing life. With the origin of life a new course of change, known as biological evolution or organic evolution, had set in.

There are three marked features of this biological evolution: complexity, diversity and adaptation. The primitive, simple forms of life underwent changes through millions of years and gave rise to more and more complex organisms. The evolution of different plant and animal groups showing various degrees of complexity in structure and function culminated in flowering plants and vertebrate animals.

Among the vertebrate animals, last came man related to monkeys and apes. Again, the immense variety of plants and animals differing in shape, size, colour, structure, place and mode of living is the outcome of organic evolution or biological change of the pre-existing simpler forms. Therefore, it can be said that all the existing living forms, including man, are closely or remotely related to one another, through a common ancestry. Another point of significance is that each kind of plant and animal today is the result of millions of years of biological evolution; and one form of life once lost cannot be recreated.

With the appearance of man on the scene of organic evolution, another course of evolution - the psycho-social evolution or a process of change through the mind and thinking and the formation of society - began as a part of the biological and universal evolution. Man appeared as a product of biological evolution, brought about by the same fundamental causes. Biologically, man may be considered an advanced ape. Initially he had to face the same competition and struggle for survival as other organisms. As a biological being he is a land animal, habitaully walks on two feet, lives in organized groups, and has scanty hair on the body.

4.1.6 Man-made environment - a part of nature

Man, by his superior brain power, skilled hands and a few other physical attributes, has gradually gained superiority over the other living things. He has a stronger memory and power of thinking. Man has also strong emotions of love, joy, hatred and anguish. He has some purpose and direction in his activities to be happy, secure and more comfortable in life. He can develop the power of articulated speech and writing to communicate and record his ideas and experiences for the use of other members of the same generation and also those of the next. So he is not only an outcome of biological heredity, but also a product of socio-cultural inheritance. Man has acquired the capability of preparing tools and improving upon them.

All these developments have enabled man to understand his surroundings and study natural laws. Through the gradual accumulation of knowledge and improvement of tools, he has gained an ever-increasing power to manipulate his environment to his advantage. He has built shelter for himself, and mastered the means of production of his food and other materials of comfort and safety.

The increased ability of the human brain to receive sensations, and the capability of abstract thinking and foresight together with the power of communication through written language have made man drastically different from the rest of the organisms.

Man's special responsibility

It has to be emphasized that the basis of human power and superiority lies in his knowledge about the environment. In spite of his tremendous power of tampering with the environment man can change neither the natural laws nor the basic nature and requirements of life. Man can go anywhere - to the top of the highest mountain, into the abysmal depth of the ocean, or even escape from the earth into space or another planet. But everywhere in order to sustain life and perpetuate his kind he will have to carry with him all the basic needs of life or to create an imitation of his earthly environment obeying the same fundamental principles of nature. Therefore, man has a special responsibility towards the environment, to himself and also to other fellow living beings.

4.1.7 Earth as the home of life

So far as is known the phenomenon of life is limited to the planet earth because only it has all the physical conditions necessary for the continuance of life. The essential conditions include the presence of: (i) those chemical elements that go to make up the protoplasm. These elements must be available in such particular forms as can be used by the living organisms and not in any other form; (ii) light and heat from the sun as solar energy for the plants to synthesize organic compounds usable as food by plants and animals, and also for the maintenance of temperature and weather conditions suitable for sustaining life; (iii) an atmosphere protecting from cosmic radiations harmful to life and containing oxygen to support life, and (iv) water.

Even on this earth the optimal conditions for the sustenance of life are not available everywhere. Only a limited area provides the congenial conditions for life. Again, all types of environments are not open to all kinds of organisms. For example, aquatic organisms cannot survive on land and terrestrial organisms cannot live in water.

The global environment consists of three main subdivisions: (i) the hydrosphere which includes all the water (liquid) component of the oceans, seas and rivers and on land, (ii) the lithosphere comprising the solid components, i.e. rocks, soil and minerals of the continents and other land masses, and (iii) the atmosphere formed of the gaseous cover which envelops the hydrosphere and the lithosphere. The entire inhabited part of the earth including the living and the non-living components forms what is known as the biosphere.

During the early stages of its formation the earth probably lost some materials in the form of lightest gases. But by the time the condition stabilized to become suitable for the origin of life, this process of material loss was reduced. At the same time, there has been little inflow of material from outside the earth in significant amount. Therefore, the earth together with its atmosphere can be considered a closed system. The amount of important materials essential to life, such as, oxygen, carbon, nitrogen, water, is finite and the supply in forms that can be used by life is exhaustible.

For energy, on the other hand, the earth is an open system. The earth perennially receives energy from the sun in the form of heat, light, X-rays and in many other forms. Energy is produced in the sun by certain reactions in which matter is transformed into energy.

Some forms of energy which are harmful to life are filtered by the atmosphere. Only a small quantity of the total energy received from the sun is utilized by the living organisms for their energy need. An enormous amount of energy is radiated by the earth back into outer space.

4.1.8 Try yourself

1. Prepare lists of objects and happenings around you at two different times and at two different places.

2. Try to find out the natural source of any two man-made items familiar or useful to us.

3. Try to find out if it is possible to have a situation where no matter or change of any kind is involved. Discuss it with others, if you find any.

4. Find out the differences between the human society and the society of ants, bees and termites.

5. Discuss a situation where man can liberate himself from the earth and continue to live for a long time.

6. Explain the meaning of man-made environment.

7. How does the man-made environment affect our species and its continuation.

8. List the important materials which are essential for life on earth.

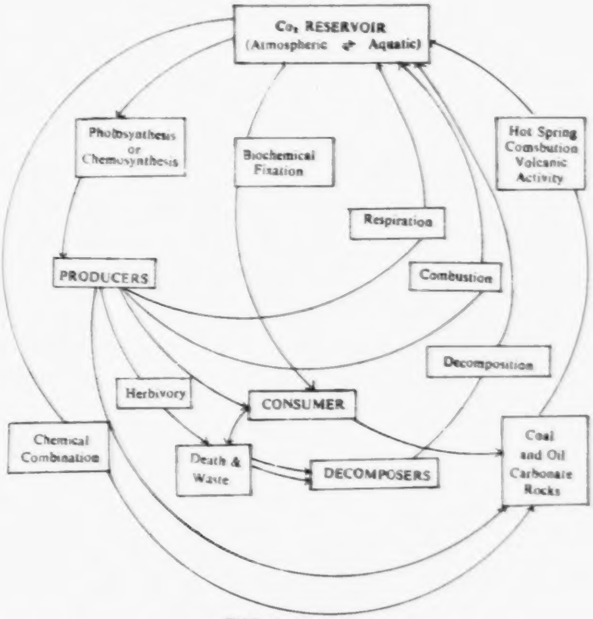
4.2 Pathway of matter and flow of energy

4.2.1 Recycling of matter

We know that the source of matter for living substances is the earth. The source of such matter in the earth is finite and limited. The matter in the living things differs from that in the non-living world not only in the proportions of various elements but also in the type of substances that can be used by the living forms. It means that only some materials can be selectively incorporated into the body of the living organisms. The elements and compounds that are useful to the plants and animals are, therefore, all derived by the organism from the physical environment and these constantly move back into the non-living world during the life and death of the organism, to be useful to other organisms again. This kind of exchange of materials between the living and non-living world may be described as the cycles of matter. A few cycles of matter which are important to life are discussed below.

The carbon cycle

Carbon is perhaps the most essential element/constituent of all major organic compounds of the protoplasm, namely, the carbohydrates, proteins, fats and nucleic acids. There are three main sources of carbon in the non-living world: (i) the carbon dioxide of the air and that which is dissolved in water, (ii) the rocks in the earth's crust containing carbonates, and (iii) the fossil fuels like coal and petroleum. The carbon of coal, graphite, petroleum, the solid carbonates and the like are not usable for life unless they are burnt or chemically changed. Green plants trap carbon through the process of photosynthesis to produce carbohydrates and other organic compounds in the plant body. These organic compounds are passed from the plants (producers) to the herbivorous and carnivorous animals (consumers). It may be pointed out that during photosynthesis energy is also built into the organic compounds. During the process of respiration in plants and animals carbon is released back to the surrounding medium in the form of carbon dioxide.


Co$_2$ RESERVOIR
(Atmospheric ⇄ Aquatic)
Photosynthesis or Chemosynthesis
Biochemical Fixation
Hot Spring Combsution Volcanic Activity
Respiration
PRODUCERS
Combustion
Decomposition
Herbivory
CONSUMER
Chemical Combination
Death & Waste
DECOMPOSERS
Coal and Oil Carbonate Rocks

THE CARBON CYCLE

Fig. 6 The carbon cycle

The dead bodies of plants and animals as well as the body wastes which are accumulation of carbon compounds, are decomposed by special groups of minute organisms. Due to decomposition, carbon is released in the form of carbon dioxide.

If the process of decay is extremely slow (say, in the case of death of a large dense forest) large masses of carbon compounds may be accumulated. This huge mass of organic bodies buried inside the earth may be transformed into coat or oil. Similarly, carbon may be locked up in the hard carbonaceous shells and skeletons of animals which the decomposers cannot affect. But the main pathway in the carbon cycle is from the earth's air (atmosphere) or water (hydrosphere) into living systems and back (Fig. 6).

The oxygen cycle

Oxygen is another essential element both for the living body and its life processes such as respiration. Oxygen required for respiration in plants and animals enters the body directly from the surrounding medium, that is, from air in the atmosphere or that dissolved in water. Oxygen returns thereafter to the surroundings in the form of carbon dioxide (combined with carbon) and water (combined with hydrogen). Oxygen as an element also enters the body of plants as carbon dioxide and water during photosynthesis and is released in the form of molecular oxygen as a product of the same process (Fig. 7).

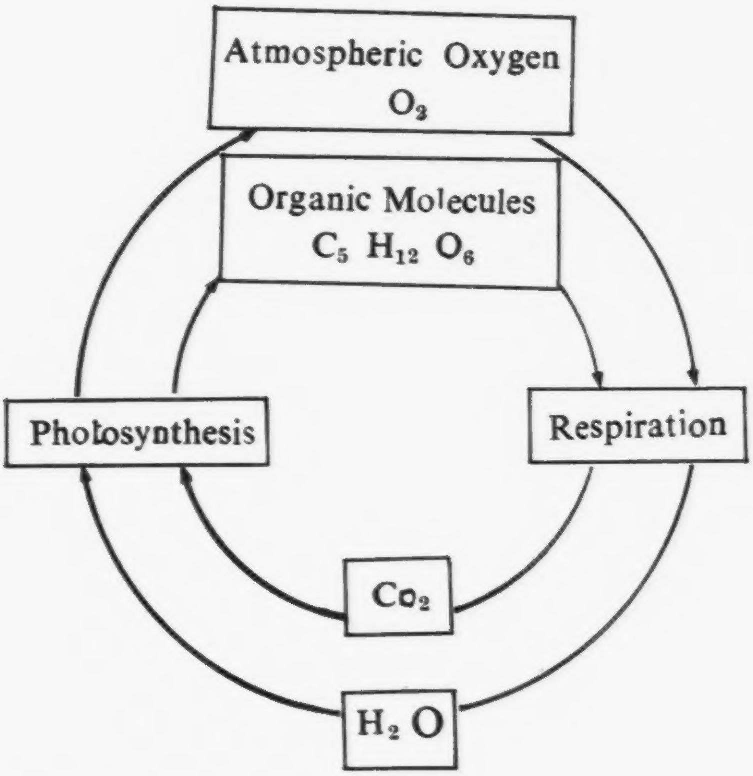


Fig. 7 The oxygen cycle

The nitrogen cycle

Nitrogen is an essential constituent of proteins that form the essential structural and functional component of a living organism. Nitrogen forms the three-fourths of the air, but it cannot be used in that form by most of the organisms.

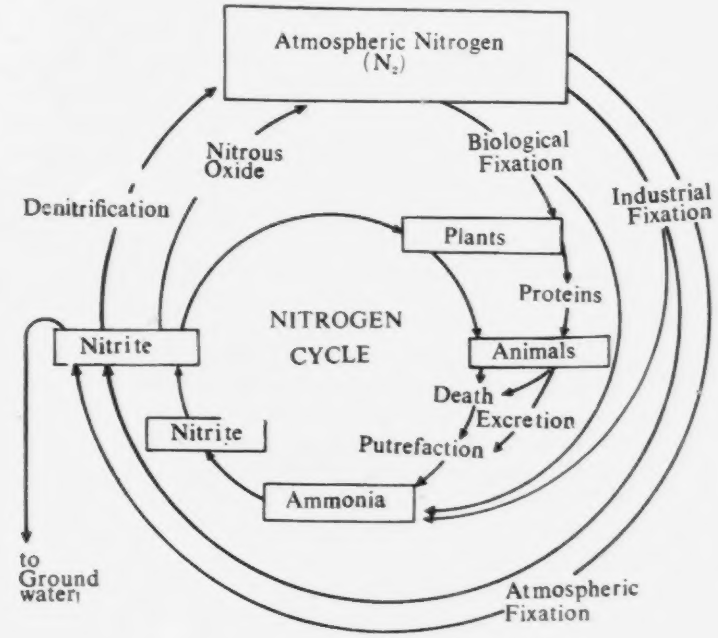

Atmospheric Nitrogen
(N_2)
Nitrous Oxide
Biological Fixation
Industrial Fixation
Denitrification
Plants
Proteins
NITROGEN CYCLE
Nitrite
Animals
Death
Excretion
Nitrite
Putrefaction
Ammonia
to Ground water
Atmospheric Fixation

Fig. 8 The nitrogen cycle

There are some bacteria, living in the soil or in association with some plant roots, which can combine nitrogen with oxygen to form nitrates (NO_3). Plants use nitrates to produce vegetable proteins.

A part of the plant proteins is consumed by animals and converted into animal proteins while the rest is decomposed after the death and decay of the plant body releasing its nitrogen to the surroundings. In the animal body the protein is eventually broken down into nitrogenous wastes, like urea, uric acid, ammonia, etc. or it is excreted. The dead bodies of animals and animal wastes are acted upon by the decomposers such as bacteria and fungi to form nitrites and ammonia or nitrates, which may again be used by plants (Fig. 8).

The water cycle

Life cannot exist without water. About 65 to 80 per cent or even a higher percentage of living matter (protoplasm) is made up of water. Water is not only essential to organisms as a constituent of the body or as an important nutrient, but it also influences the life of the organisms through weather and climate. Water is the exclusive source of hydrogen for the living organisms. It is also the medium in which a large number of organisms live.

There are two overlapping water cycles in nature - one the larger cycle, not involving life, and the other, the smaller cycle through the living world (Fig. 9).

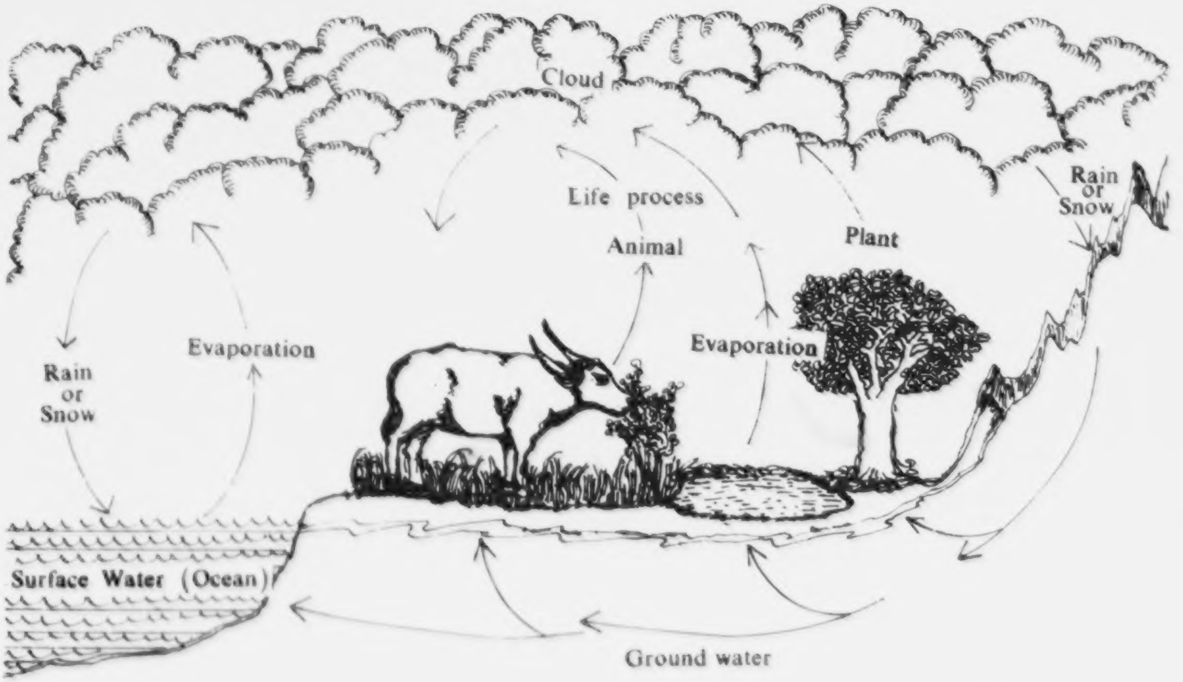


Fig. 9 The water cycle

The global water cycle is an observable and familiar process. It consists of evaporation of water into the atmosphere from the oceans, seas, rivers and lakes which are part of the hydrosphere. The water vapour subsequently cools and condenses to form clouds and water. The water comes down to the earth as rain and snow or it may fall directly into the ocean. If it falls on the land mass it again flows back into seas and oceans through rivers and underground movement.

It may be mentioned that a large amount of water remains underground and in perennial snow in the poles and mountain peaks above the snowline.

The entrance of environmental water into the living system and its return is also a massive cycle differing considerably from the global water cycle. Aquatic organisms absorb water directly from the surroundings and release it back in the form of excretion during their lifetime. After death, the water returns to the surrounding medium through the decay of organisms.

Land organisms are more closely related to the basic environmental water cycle. The land animals drink water from the surface fresh water sources and with food; the plants absorb water from the soil. The organisms retain some amount of water in their body and the remainder is excreted into the air. This may raise the humidity of the atmosphere. The movement of water from the hydrosphere through direct evaporation and through the living organisms affects the climate. The trees of the tropical forest areas keep the atmospheric humidity high and cause more rainfall. After the death and decomposition of land organisms the water in their bodies comes back to the environmental water cycle.

Other materials

In addition to water, many other inorganic substances and minerals, such as phosphorus, calcium, etc., are essential for the life of the organisms in small but definite amounts. These are found in the crust of the earth and also dissolved in water.

Plants take in the mineral constituents in solution from the soil with the help of their roots. Animals obtain their minerals partly from the plants as food and partly from water. Some animals get their supply directly from materials in the soil. Minerals return to the environment after the death of the organisms and decomposition of their body by the action of the decomposers. In animals, a large amount of minerals are excreted back to the soil or water. Some of the organisms, like the molluscs and corals, deposit a substantial quantity of calcium in their non-decomposable shells and skeletons that do not come for quick recycling.

Living organisms thus happen to be unique organizations (both structurally and functionally) made up of matter and energy borrowed only temporarily from the environment. Regular recycling is not restricted to and necessary merely for materials like carbon, oxygen, nitrogen, water and minerals, but it involves overall life and death in order to perpetuate life as a phenomenon.

4.2.2 Flow of energy

The energy used by organisms for such life activities, growth and metabolism is derived from solar radiation mainly in the form of heat and light (Fig. 10). The energy also maintains environmental temperature, and regulates weather and climatic conditions. From our experience we know that food supplies the different materials which form the body structures and other substances required for our internal working. Food also provides the energy we require. If we look around

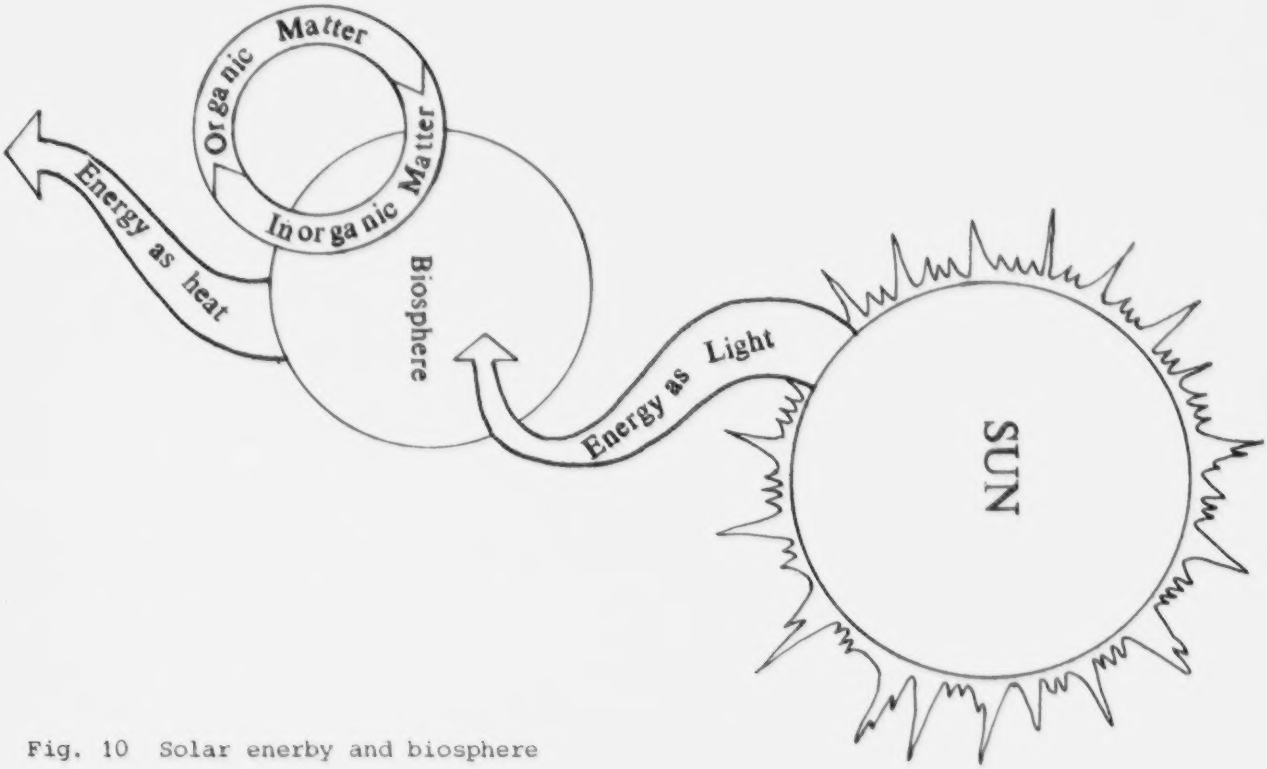


Fig. 10 Solar enerby and biosphere

we see that all animals, except a few, take food. Some animals are carnivorous and eat animals or animal products. Some are herbivorous and get their energy from plants. But what do the plants eat? The plants prepare their own food by a process called photosynthesis. They absorb carbon dioxide from the medium in which they live, that is, air or carbon dioxide which is dissolved in water, draw water from the soil (or aquatic medium) and capture energy of the sunlight to produce or synthesize carbohydrates with the help of their own green pigments, called chlorophyll. The plants also synthesize proteins and fats. So the green plants which produce this food are called producers. The animals that consume this energy as food are called consumers. The non-green plants like the fungi and some bacteria, which are incapable of producing their food, live on the dead and decaying plants or animal parts, and are consumers of a special kind, called the decomposers.

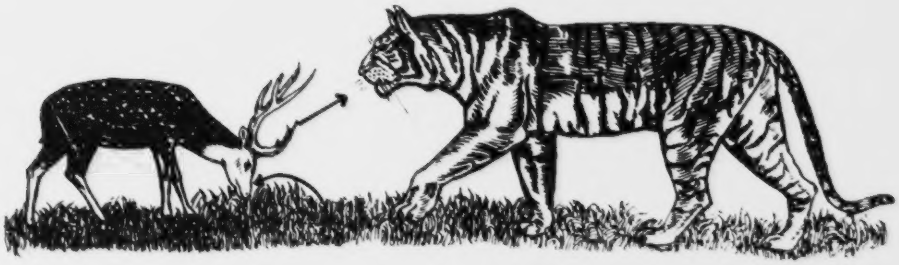


Fig. 11 A simple food chain showing trophic levels

The herbivores like the deer and the goat who derive their food (or energy) directly from plants (the producers) are called the first order consumers. The carnivorous organisms like the tiger and the lion are the second order consumers. Each step in the food chain represents a trophic level (Fig. 11). So, the energy from the sun enters the living world through photosynthetic (green) plants and passes on from one organism to another in the form of food. At the same time the plants which trap the solar energy and act as producers also use up some energy in their own life processes. Only a portion of the energy trapped can be taken up by the primary consumers. Similarly, the primary consumers (animals that are much more active than the plants) also use much of the energy acquired before it can be consumed by the secondary consumers. So at each stage of energy transfer, a considerable amount of energy goes away to nature. The decomposition of dead bodies of organisms also releases chemical energy, and eventually all the solar energy that entered the living system through the producers goes back into the non-living world, of course, not in the form of light but as heat.

So we have seen that matter and energy are the two constituents of life. We have also seen that energy in living things is made usable in the form of chemical energy and transferred in the living world through food. The word 'food' means 'materials containing energy that organisms can use'. Food is the means of transfer of both matter and energy in the living world. Therefore, an understanding of food relations is very important for understanding the environment.

Food relations

Food relations in its simplest form, say, grass-deer-tiger, representing a single producer, consumer and secondary consumer, is called a food chain (Fig. 12). But

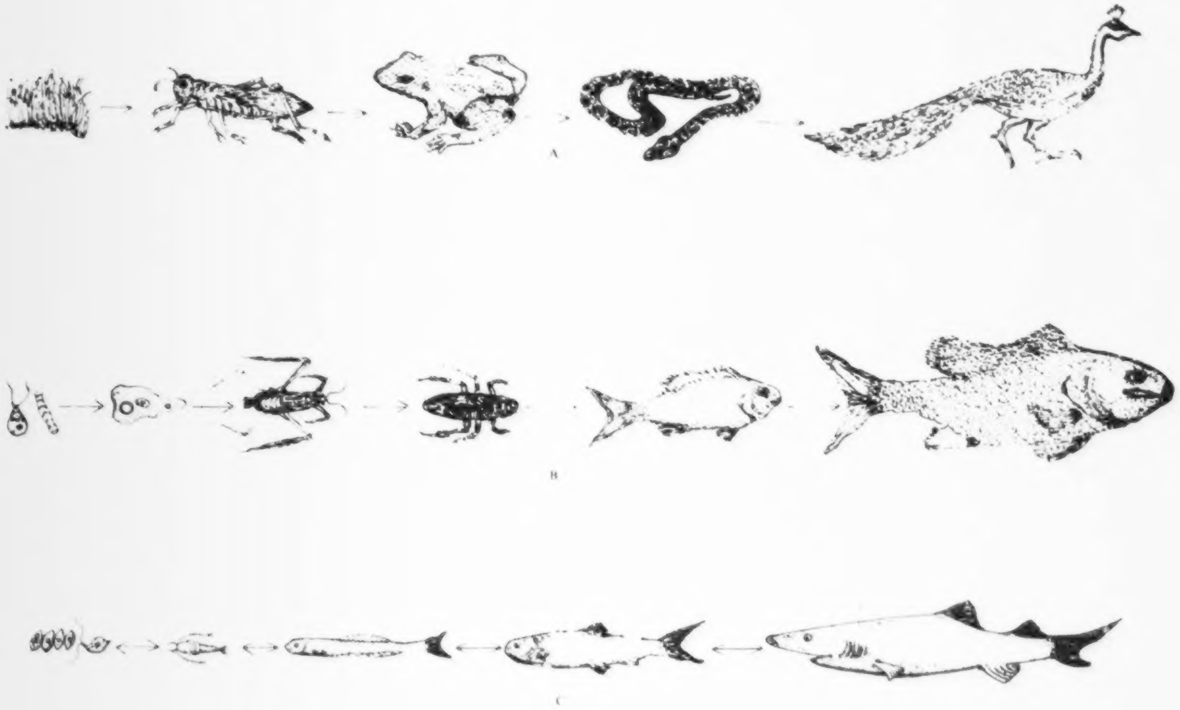


Fig. 12 Some representative food chains (a) Terrestrial, (b) Fresh water, (c) Marine.

the food relationship is hardly ever that simple. A herbivore eats many different types of plant or plant products. Many types of animals other than the tiger derive food from herbirorous animals. Ticks and mites, leeches and blood-sucking insects (mosquito) are dependent on the herbivores and even on the carnivores. The food relation - a complex network of food chains therefore, forms a complex food web (Fig. 13). The food web becomes more complicated owing to the variability of tast and preference, availability and compulsion and several other factors at each level.

Another feature, found quite often but not universally, is that in any one chain the members at the successive levels are larger in size and smaller in number. For example, in a forest the small herbivorous insects are larger in number than the insectivorous birds which are bigger but fewer. Again, the preying birds like the hawks or the carnivorous animals (tigers) are bigger in size but fewer in number. That means, the number of organisms is less at each successive food level and the graph of numbers of organisms assumes the shape of a pyramid. This relation is expressed as the food pyramid. It is to be noted that the increase in the number of one kind of animal would depend upon the availability of the food organisms at the lower level. For example, the number of a particular herbirorous insect would increase if more of its plant food was available. This would mean more of food being

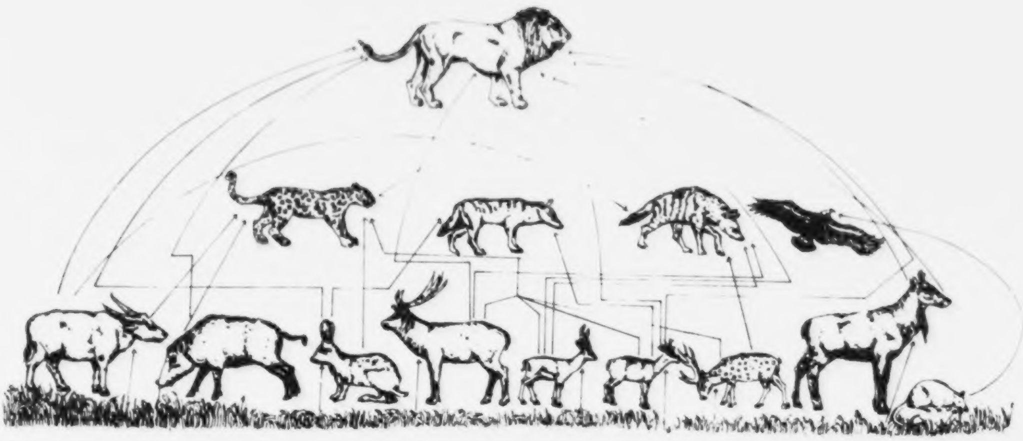


Fig. 13 Food web in a forest.

available not only to its prey, say the frog, but also to other animals like a bird which feeds on that insect even as a second choice. So, there is a balance of food affecting the exchange of materials and energy and holding a grand balance of nature. But this balance has a scope of adjustment, that is, the balance is not static. It is dynamic and fluctuates within certain limits.

The energy of the sun and the materials from the earth enter the living systems through the producers and flow through the living world as food. Man is a part of the system.

4.2.3 Man alters nature's balance

Man and the food chain

Initially, man as a biological being had to compete with other organisms. He, is an animal, is a consumer. As a hunter, he had been primarily a second order consumer living mostly on grazing animals, insects and fish. He could also occasionally act as a first order consumer when he ate fruits, nuts and other plant products.

The development of agriculture also helped him to become more efficient both as a primary and a secondary consumer. He grew plants for products of his own consumption as also grasses and fodder for his animals like cattle, sheep, goat, pig and poultry.

The development of agriculture enabled man to shorten his food chain and to partially liberate him from the uncertainties and hardships of a hunter and food-gatherer. With further progress he tried to bypass the natural food web by trying to eliminate the insects which fed on the cultivated plants and the animals that tried to eat his food plants or harm his domestic animals.

Man and energy

Man as a biological being is only a part of the energy flow mentioned above. But as a civilized being he uses much more energy than is available to him as his food. With the development of human civilization the pattern of energy consumption has greatly changed. His requirement of energy and utilizable capacity of energy have vastly increased. A tremendous amount of energy is required for his agriculture, industry, transport, communication and war. He has been deriving this additional energy from wood and charcoal, and by making the draught animals (oxen, camels, horses, etc.) work for him. At present the use of fossil fuels like coal, oil and gas, which are of limited supply, has greatly increased. The energy of wind and water current also is in use. It may be noted that the ultimate source of almost all the above sources of energy is, in fact, the solar energy. Recently, man has started tapping nuclear energy (by fission of atoms) which has its own hazards. Therefore, the energy profile of the human civilization has great environmental implications.

Modern human life and activities, and the man-made civilization and environment do not exactly fit in with the natural environmental forces. The need of food for the increased populations of different taste and fancy and the desire for automobiles, aircraft and rockets for transport and travel, electric and electronic devices for communication and computers and spaceships and explosives for war require many types of materials in enormous quantity. With the gradual progress of human civilization, the biosphere also started to be transformed into a human mind dominated environment or 'noosphere'. Man has altered many of the chemical cycles of nature by supplying materials like man-made nitrates and prosphates as fertilizers. He has also changed the regional cycles by transporting these chemicals to different areas. In other words, the biosphere started changing from self-sufficient system to a 'resource' for one of its inhabitants - man.

4.2.4 Resources

The word 'resource' means that which is needed in relation to a purpose. In the human context it would mean the material and energy and their sources that man needs for his survival and prosperity. The resources, therefore, would vary, from society to society, in time and space, the stages of development and specific culture. Gold, silver or diamond is not a resource for the monkey. Uranium (a radioactive substance) was not regarded as a resource in the nineteenth century. The aircraft fuel is not a resource in a tribal community.

Energy, air, water, soil, minerals, vegetation and animals are important natural resources. In fact, all the resources are derived from the natural environment.

Resource distribution

The availability of resources and the capacity of their exploitation are not uniform in all parts of the world. Therefore, there is a great competition between the nations for grabbing the resources. There is also a grave disparity in the distribution of resources, goods and services among the various sections of the people in the same country. Most of the world resources are enjoyed by a comparatively few nations and by fewer people within a country resulting in a very unequal standards of living. While some members of the species are living in luxury, the majority are languishing in poverty.

The resources of the human society are usually classified as renewable and non-renewable. Renewable resources are those that have the inherent capacity to reappear (due to quick recycling), reproduce, replace or maintain themselves if managed and used judiciously. Plants and animals, domestic or wild, which can reproduce at a normal rate and maintain themselves in spite of killing or death, land and soil (well managed) and water derived from the normal water cycle are the examples of renewable resources.

Non-renewable resources are those that do not have the inherent capacity to maintain themselves by replacement or recycling in practical or foreseeable terms. Substances which have too long a recycling time for human management are also non-renewable. The fossil fuels like coal, petroleum, or gas and most of the underground water are non-renewable resources and can be exhausted if used injudiciously or too quickly.

So much materials used by the industrialized man which include almost all metals like iron, copper, aluminium, zirconium, etc., which are used for his technological development, scientific experiments, comfort and war, are not used by other organisms. Some of the minerals (metals) like magnesium, copper, etc., which are required by plants and animals in small quantities are available to them through food and they come back to the living system through a quick recycling.

Use of resources

Man's traditional energy sources such as wood and charcoal, are renewable resources at least in theory. But, through large-scale deforestation and injudicious and wasteful use, they have become non-renewable in many areas. Man's use of such fossil fuels as coal, petroleum and gas is increasing at such a fast rate that there is a real threat of depletion. Although man has discovered new sources of metals and of fuels faster than he could consume them, this cannot continue indefinitely. We should see that the next generations to come are not deprived of the reserved fund of the present resources at least till such time that an effective resource substitution is made.

4.2.5 Try yourself

1. Trace the carbon-dioxide-oxygen relation between a plant and an animal.
2. Note the importance of the organic wastes in the nitrogen cycle.
3. Discuss reasons why many ancient civilizations and old cities were developed near rivers.
4. Discuss the importance of photosynthesis in the life of plants and animals.
5. Construct a food chain placing very familiar organisms around you.
6. Construct a food-web placing the familiar organisms in the scheme.
7. Find the position of man in a food web.
8. List the materials commonly used by the present generation that were not in common use in the previous generation. Prepare the list in consultation with an elderly person.

4.3 Ecological system

As mentioned earlier the earth is the home of diverse life forms of plants and animals including man; but life as we know it is limited to the relatively thin surface zone on our planet. The life supporting zone of the earth is called the biosphere. The entire biosphere is not equally hospitable to life, nor can every part support every form of life. Within the biosphere manyspecific identifiable factors interact continuously and differentially to produce a number of distinct habitats - the overall conditions where particular kinds of organisms live. The environment involves the sum total of these interrelations.

4.3.1 Ecosystems

The functional unit of the biosphere that can be identified and studied is known as the ecosystem. An ecosystem includes both the organism and the non-living environment, each influencing the property of the other and both necessary for the maintenance of life. A pond, a forest, and a grassland are examples of ecosystems. An ecosystem can be conceived in various sizes. It can be artificial or natural. A large grassland, a small tract of a forest, a single dead log, an edge of a pond or a river, a village or a city, any part of the ocean, even an aquarium or a manned spaceship can be regarded as 'ecosystem'. As long as the major components of the environment are present and operate together to achieve some functional stability, even for a short period, the entity may be considered an ecosystem.

The biosphere is actually the sum total of all the ecosystems and integrated as a series of gradients to produce a universal environment in such a way that the chemical composition of the air, water and minerals (atmosphere, hydrosphere and lithosphere) remains constant for a very long time. Since ecosystems are primarily functional units, it is difficult to exclusively separate one ecosystem from another. The shore of a pond may separate the adjoining grassland from the pond, but some birds may break the barrier and feed on the fishes and crabs of the pond.

In the biosphere any recognizable unit or an ecosystem, such as a lake, a river, a forest or an open sea, has structural and functional components. For the convenience of study, the environment can be divided into two components: (i) physical or abiotic, that is, all interactions between the living entities. Structurally therefore we can recognize (i) abiotic substances and physical forces, (ii) producers or autotrophic organisms (which can produce their own food - mainly plants), (iii) consumers or heterotrophic organisms (mainly animals which ingest plants) and (iv) decomposers or saprophytes (organisms which break down the dead protoplasms to derive their food).

If we compare the structures of the ecosystems taken from very different parts of the biosphere, say, one terrestrial and another aquatic, we would find that the exact composition of the non-living component, say the medium, availability of oxygen, temperature, pressure, would greatly vary. They would also be populated by entirely different kinds of organisms. Yet the same basic ecological components will be found to be present and functioning much the same way in all the ecosystems.

4.3.2 Abiotic factors

All the abiotic factors are probably not known as yet and the implication of many have not been understood properly. Some of the most important non-living factors that determine the environment are: (i) the climatic factors which includes fluctuation of weather - rainfall, snowfall and humidity, evaporation, temperature, pressure, wind and seasons, (ii) edaphic factors and (iii) the medium. The factors do not operate in isolation, but interact to affect the life of the various organisms.

Organisms also grow in and adjust to a particular environment or an ecosystem according to the climatic conditions and their own adjustability. Some form of life can adjust to wide variability, others are more sensitive. The life cycle of each kind of organism (or species) is closely adjusted to the climatic and other conditions.

In many plants and animals the growth and activities are directly influenced by environmental temperature. The rate of growth and activities are increased considerably by warmth and decreased by cold. The temperature of a region is generally dependent on the latitude and the altitude. These factors also determine to a great extent the type of vegetation and animal life that will live in a region. The higher latitude areas are colder than the areas near the Equator. Similarly, higher altitude areas also show polar climates. And so, the vegetation and animal life of lower-latitude-high mountain regions show great similarities with even the low areas in higher latitudes.

4.3.3 Biotic factors

The biotic factors of an ecosystem can be broken up into the following levels of biological organization: (i) individual, (ii) population, and (iii) biotic community. Thus an ecosystem consists of a biotic community and its abiotic environment.

The biosphere is the planetary environment representing various habitats in which plants and animals live. The two subdivisions of the biosphere are the terrestrial (land) and the aquatic (water). The two components of the terrestrial habitat are the soil (substratum) and air (medium). The aquatic environment can be divided into marine (saline water) and freshwater.

Under the influence of/determined by the various regional climatic factors, substrates and physiographic conditions the terrestrial environment is divided into several habitat zones or biomes. The biomes are natural ecological groupings of distinct communities. The main terrestrial biomes are: desert, grassland - tropical and temperate, rain forest, deciduous forest, taiga and tundra (Fig. 14).

Similarly, the marine environment may be subdivided into distinct habitat zones such as seas, shores and estuaries. Streams and rivers, lakes and marshes are freshwater habitat zones.

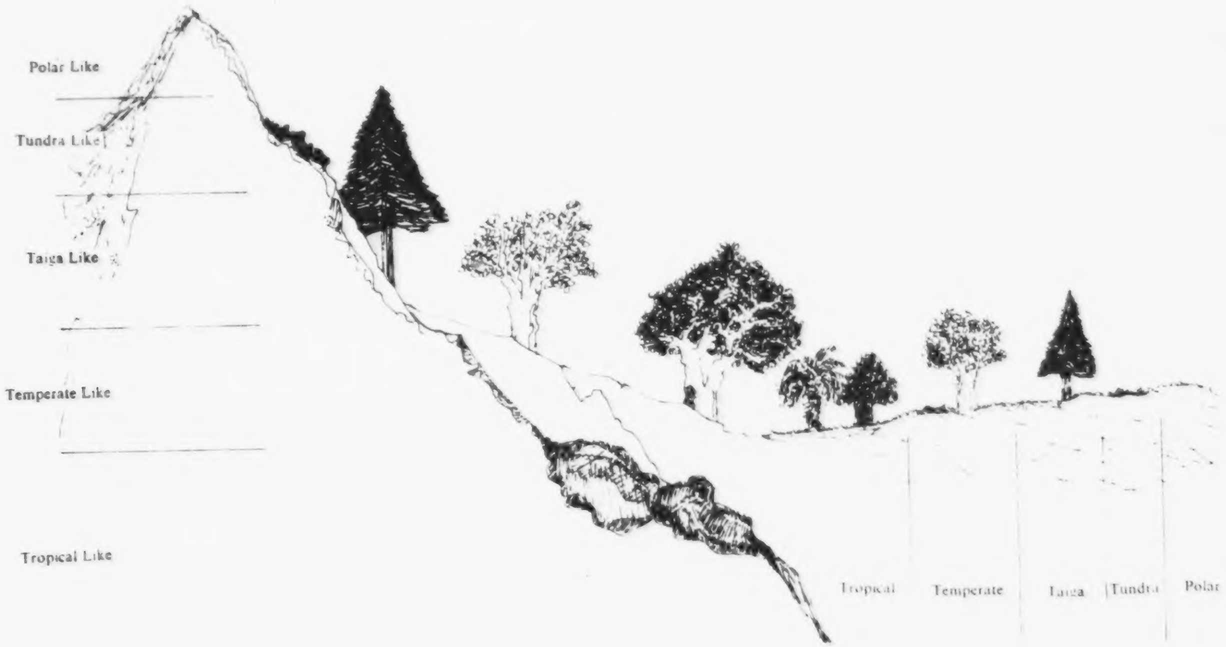


Fig. 14 Horizontal and vertical sequences of biomes.

(i) Individual

The living organisms as they occur and are observed concretely appear as distinct individuals. An individual is a distinctly organized unit of life usually with systems and organs, tissues and cells and capable of functioning independently. The individual organisms can be recognized as belonging to different kinds, such as men, cats, dogs, tigers, deer and roses. The members of each kind are said to be belonging to a species.

(ii) Species and population

It is difficult to describe a species by a single definition. The members of a species are capable of naturally interbreeding among themselves to produce fertile offspring in successive generations. The males and the females of a species may differ in certain characteristics but are interdependent, reproductively, enabling them to live in cohesive association.

The members of a species have also many other common bonds to unify them into an associated natural grouping. Each species has a common way of interacting with the environment and a distinct way of living (ecological niche).

One important feature of a species is that all its members neither restrict themselves within a single area nor are the individuals usually found to live alone. They usually live in groups for reasons which have been stated earlier. A geographically localized group of individuals of the same species at a particular time represents a population. For example, the population of students in a class, the human population in a village, the fish population in a pond or the grass population in a lawn.

The population of an area does not remain constant for ever; it may vary at different points of time. So, for a description of a population we should consider several parameters like (i) the species or kind of organisms, (ii) specific amount of space or geographical area, (iii) the time at reference, and (iv) the number of individuals present.

To denote space, in connection with terrestrial organisms, often a unit of area or two dimensional units of space is mentioned.

In case of an aquatic organism, three dimensional space is considered.

The term 'population' is also often used to express population density, which means the number of individuals per unit of area or of space. Population density is only a measurement and it is used in relation to some purpose, problems or studies.

Both the size of a population and the population density of an area vary. Individuals are added to a population (i) by natality (birth or hatching or germination) and (ii) by immigration (moving in from outside). A population tends to decrease (i) by mortality or death and (ii) by emigration (moving out). Obviously, in the case of plants, which are not mobile, the question of immigration and emigration does not arise, although seeds may be carried long idstances by wind and water. Migration of a population is not a determinant of population size. If the environment remains the same, the population maintains a balance between loss and replacement of members.

The population size is affected by change in the environment. A population tends to increase in size as long as individuals get enough food and space. With the increase of population food and space available to the members of a population become gradually less than the requirements. This, in turn, may lead to the fall of natality (birth rate) or to emigration. But, a sudden change in the environment, say, deterioration in the food system or destruction of the habitat can cause large-scale deaths. Any sudden or drastic change in the environment destabilizes the population and may even exterminate the population. Thus, food and space are major limiting factors of a population, which operate through different determinants (birth rate and emigration) to bring about the stabilization of a population. Again, the factors influencing the determinants of population density are external to the members but operate through the behaviour of the members.

A particular population is affected by abiotic factors like the duration and intensity of sunlight, temperature, fluctuation of rainfall and humidity. Some population adjust to weather and season changes through migration. Biotic factors affect chiefly through relation (producer-consumer relationship) or by producing diseases in the population. Environmental factors can also influence a population by affecting other populations.

Human population

Human population is unique in many respects. Man as an animal is perhaps the most abundant species, only comparable to the cod-fish, sardines and the houseflies. And in total bulk of the protoplasm, man might win over all other animals. The pattern of human population and population growth depends upon many complex factors, such as geographical factors like climate, location of natural resources, and socio-economic factors like availability of jobs and amenities. The size and the rate of growth of a population, the birth and death rates, all have great significance on the standard of living of the people, their aspirations and the economic and social development. The study of the trends in human population growth and the prediction of future developments have given rise to a special branch of knowledge, demography.

The human population is increasing at an enormous rate. Unlimited population growth has severe environmental implications leading to overcrowding and to decrease in per capita income, food, land, fuel, and consumer goods and services. But the rate of growth is not uniform in all the countries or among different groups within the same country.**It is** also related to the developmental stage of the society.

The birth rate in a human population is regulated more by social factors than biological. The age of marriage, marriage dates, contraceptive practices are some of the factors. Similarly, the death rate is regulated by the nutrition status, hygienic practices, sanitary conditions and medical facilities and standards.

The human behaviour and activity cannot be understood by biological principles alone. The population study should consider, as indicated earlier, the birth rate, immigration, death rate and emigration. Human population studies need to apply more sensitive measures such as the number and proportion of the different age groups requiring education, training and employment of various kinds. Various other criteria, such as old age and economic status are also required for economic and social welfare planning. Another important feature of the human population growth is that the population in the developed countries such as the United States of America, France, West Germany is comparatively more stable than in the developing countries like Bangladesh, India or China. Both the birth rates and the death rates in the developed countries are comparatively lower. In general there is an inverse relationship between the population growth rate and the economic development, the level of industrial development and the education of the people. This relationship also holds good amongst the various groups within the same country.

Rapid urbanization is another recent trend having environmental implications, particularly in the developing countries where urbanization is faster than economic development.

(iii) Biotic community

The smallest number of interrelated populations (which would still be many) living in a common environment which can survive in nature is called a biotic community. A biotic community is a constituent of an ecosystem. The different species of organisms, both plants and animals, in a pond constitute the pond community. Similarly, the interrelated organisms in any ecosystem, say, a track of forest, a lawn or an area of a desert, constitute their own biotic communities.

What is the nature of relationship between the various populations of a community? The most important is the food relationship. This is also known as trophic organization which is concerned with the transfer of material and flow of energy within the community, discussed earlier.

The relationship between one organism and another has historically evolved through interaction, based on the requirement of food, shelter and habits of the organisms living in the community. The nature of some of these relations can be expressed in the following terms.

(i) Predation - It is a direct food relation between animals in which one animal (the predator) captures and feeds on another (the prey). For example, the relation between the tiger and the deer, the lynx and the hare, the snake and the rat.

(ii) Scavenging - Some animals such as a vulture or a hyena feeds on other animals which have died or have been killed by another organism.

(iii) Parasitism - Parasitism as a mode of relationship between organisms in which one organism (the parasite) not only derives its food from another organism but spends a part or whole of its life on the host. Ticks, mites and lice are external parasites. Amoebae, tape worms, flukes and various bacteria re internal parasites of vertebrates. Dodder (Caseutta sp) is a common plant parasite. The parasite-host association is helpful to the parasite and harmful to the host. In some cases the parasite causes a severe disease in the host, that may even be fatal to the host.

(iv) Commensalism: It is a mutual relationship between two organisms where one organism lives attached to another but not harming the host. The host may even be benefited marginally. The attachment of the sedentary sea anemone on the body hermit crab, barnacles on the body of the whales and the Remora (a fish) to a shark, are the examples of such an association.

(v) Symbiosis - Symbiosis is a relationship of two organisms where both the partners derive mutual benefit from each other. Lichens growing on rocks and barks are an association of two plants - fungus and alga. The green alga prepares the food for both and the fungus gives the support and provides raw materials for the preparation of the food.

(vi) Competition - Competition is a relation of organisms within a community, which involves struggle for the same type of food, shelter, nutrients or even sunlight. Competitions are not necessarily restricted between the members of two or more species; the individuals of the same species may have to compete for survival. Trees, shrubs and herbs in a forest strive for sunlight, nutrients and water in the soil. The different carnivorous animals, say, the tiger and the leopard may also compete for their prey.

There are several other types of associations, where the relation may not be that close but is definite. Many animals help in the pollination of flowers, dispersal of seeds and fruits, some birds feed on the ticks (parasites) on the body of the cattle; a large number of insects, birds and other organisms take shelter on or under the trees.

4.3.4 Man and ecosystem

With the progress of civilization, man has gradually lessened his dependence on particular biological communities. At the same time he has increased his ability to replace the 'natural' communities with man-made communities to suit his needs and whims. Over a large part of the biosphere or beyond, he has become the dominant species. He has changed the abiotic and biotic landscape.

The present human population on the earth could not be supported without utilizing plants and other animals to serve and work for him through cultivation and domestication. Man's relation with many plants and animals has also grown in a special way because of his ways of living and thinking. Human relationships with other plant and animal populations can be classified into several categories; his prey (meat-yielding animals and fishes); his predators (tigers and lions); his parasites (amoebae, malarial parasites, some worms, bacteria); his inquilines, that is, the organisms which started living inside human shelters without directly being encouraged by man (scorpions, lizards, mice); opportunists, the organisms which took advantage of his agriculture and other activities (weeds, house sparrow, robins); and the cultigens and pets (domesticated animals, agricultural plants, parrots, dogs). He has a large number of plants and animals as his enemies or the enemies of his cultigens.

Man has also changed the geographical distribution of plants and animals that developed according to their natural environment and historial adaptation. There are also examples of human introduction of animals into new areas, the Indian mongoose in Hawai, the rabbits in Australia, etc. These introductions have shown various consequences.

Another unique feature of the human species is that man has largely contained his predators by killing them or restricting them within a small area. But strongest of all is his intra-specific struggle. He has developed an enormous war machinery primarily for the defence of the territorial or group interest of nation-states, which far exceeds his defence measures for mankind against his enemy species. The global war efforts involving money, material and energy resources far exceeds the efforts devoted to providing health. Huge amounts of technological manpower, research efforts and precious land have been locked up for war purposes, which could be released for the removal of poverty and hunger, and for human welfare and the mitigation of suffering of the majority of the human population.

4.3.5 Try youself

1. Describe a living community in your locality, a garden, a lawn or a pond listing the organisms and the relationship which you may have observed.

2. What is a population? What are the main factors which bring about a change in the population size?

3. Mention a few points which make the human population unique.

4. What are the criteria by which an aquarium can be regarded as an ecosystem?

5. Name three predators from the organisms familiar to you.

6. What is symbiosis? Name any symbiotic organisms that you find in your locality.

7. In what ways can the human life be affected by parasites?

8. Make a list of the indigenous and introduced plants in your locality.

UNIT 5

5. ENVIRONMENTAL PROBLEMS AND THEIR SOLUTIONS

5.0 Introduction

The environmental problems we encounter today are the consequences of the changes brought about by man's intervention in the environment for the satisfaction of his needs and aspirations.

Within three or more million years of man's existence on the earth his progress from the 'primitive man' to the 'technological man' is a story of ever-increasing needs of materials and energy, and, his transformation from a 'creature' of the environment in his earlier stage to its 'moulder'.[1] His activities as a moulder have resulted in the changing of the environment into two interlinked components: the natural environment and social (socio-cultural) environment.[2] (See 4.1.1.)

Demands are placed upon these two components of the environment for 'the satisfaction of basic human needs and the pursuit of more ambitious goals'.[3] Basic human needs for a satisfactory human existence anywhere in the world are, in essence, universal - 'the physical needs of food, health, shelter and clothing and the social ones of education, creative employment, individual freedom and ability to participate in the prevailing social system. To be denied any of these needs is to be denied the prospect of a fulfilled life'.[4]

After the basic needs are met, man aspires to more ambitious goals. The pursuit of some of these goals such as 'avid accumulation of the products of material affluence'[5] and other features of the affluent life-style make a greater demand on the environment. The magnitude of the demands made by mankind in the pursuit both of basic human needs and of more ambitious goals in proportionately increased by the massive and continuing increase in the world's population.

The mechanisms governing the use of environmental resources of the globe militate against their use in a way that may benefit human society as a whole.[6] The resulting growing inequalities in human societies may further aggravate environmental deterioration.[6] Environmental ethics call for greater mutual understanding, a new life-style, and development patterns in consonance with the assimilative and regenerative capacity of the environment.

5.1 Environmental resources, their deterioration and possible solution

The environmental resources - energy, air, water, soils, minerals, plants and animals - at human hands 'suffer through wanton exploitation, yet often through blind ignorance, stupidity and neglect'.[7] It is essential for man's own survival to become aware of the limitations and carrying capacities of the environmental resources and to find ways and means of counteracting destructive trends and bring solutions of these problems to the doorsteps of the common man. It is high time we made a sincere effort, at every level, to understand the laws of the economics of nature and adopt them in our daily life.

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[1] UNEP. *Major environmental problems in contemporary society*. 1977, UNEP/ENVED 8 (para. 3).

[2] Ibid. (para. 8).

[3] Ibid., Paris; Unesco; August 1977, UNEP/ENVED 8 (para. 17).

[4] Ibid. (para. 13).

[5] Ibid. (para. 14).

[6] Unesco. *Education and the challenge of environmental problems*. Paris; Unesco. August 1977; Unesco/ENVED 4 (para. 14).

[7] John B.S. Coats. Foreword, *In harmony with nature*. Madras, The Theosophical

5.1.1 Our energy resources

The problems

(a) Energy inputs to the earth

Energy moves the universe. The major energy inputs to the earth are solar radiation, thermal energy from the interior of the globe and tidal energy (gravitational energy expressed through the relationship of the sun, the moon and the earth). Solar energy accounts for 99.98 per cent (173×10^{15} watts) of the total input per second.[1] About 0.1 per cent is stored by green plants as chemical energy in food.[2] A very small percentage of this energy (64×10^{15} watts) has been stored in fossil fuels (coal, oil and natural gas).[3] Energy in wood and charcoal, food substances and muscles, used by man also are derived from solar energy stored in plants. Other sources of energy are found in water and wind and in the nuclear energy obtained from nuclear reactors.

(b) Ever increasing energy demands

The three or more million years of human existence is a story of ever-increasing energy needs of man. Muscular energy was the only source of energy for the 'primitive man'. It was regularly replenished through his intake of food. This conversion of food into muscular energy was confined to the natural process of energy flow in the biosphere.

Through his progress from the primitive man to modern technological man, man entered into newer pathways of energy flow in nature to meet his ever-increasing demands for energy. In addition to food, 'the hunting man' needed energy for cooking and warming. This he procured by converting wood into fire. 'The agricultural man', in addition, turned grass into muscular energy of animals to till his fields and transport his materials. As he progressed further, he utilized wind and water to move windmills, sails and water mills. The advent of the steam engine heralded the First Industrial Revolution and that of the high speed electronic computer, the Second. Enormous amounts of energy needed by man for rapid industrial growth during the Industrial Revolution was met by the exploitation of the fossil fuels - coal, petroleum and natural gas. Not only fossil fuels but also other energy sources, especially hydro and nuclear energy, were used to generate electricity. Solar energy by direct conversion, tidal energy and geothermal energy (from volcanoes and hot springs) are also being utilized lately, though in small amounts.

(c) Dependence of industrial growth on fossil fuels and consequences

The industrial growth in the world today is totally dependent upon fossil fuels. Since their reserve in the earth's crust is limited and the demands on them by different societies are gradually increasing, their ultimate exhaustion in

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1. M. King Hubbert, The Energy Resources of the Earth, Scientific American, (New York), Vol. 224, No. 3, September 1971 (p. 61).
2. George H. Woodwell. The energy cycle of the biosphere, Scientific American (New York), Vol. 223, No. 3, September 1970 (p. 64).
3. Unesco. The Teacher's Study Guide on the Biology of Human Population. (Asia), Paris, Unesco. 1975 (p. 112).

future is inescapable. How long can the fossil fuels alone sustain the industrial civilization? According to one estimation the initial reserve of fossil fuels was about 64,000 million million kilowatt hours.[1] Up to 1970 about 1,600 million million kilowatt hours of energy have been consumed.[1] The remaining fossil fuels are made up of 95 per cent coal, 4 per cent oil and 1 per cent gas. Oil and gas account for 65 per cent of energy consumption in the world today. Further, energy consumption is increasing at the rate of 60 per cent per decade. At this rate of consumption, oil supplies may be exhausted by the end of this century, gas a decade earlier, and coal may be exploited for 300 years more. The awareness of this fuel crisis has resulted in the periodic price hikes by the oil-producing countries inflicting severe strains on the developing countries.

(d) Disparity in energy consumption

Flagrant inequalities exist in energy consumption within human societies. Thirty per cent of the world population living in industrialized regions (North America, Europe, the USSR, Oceania and Japan) consumes, today, 84 per cent of total energy being made. Only 10 per cent of the world's energy is consumed by the Asian people (excluding Japan), constituting more than 52 per cent of the world population.[2]

Privileged groups in every country are wasting energy while the large mass of the vulnerable section of the world population is finding it increasingly difficult even to collect firewood to cook their daily meal. This simple act of firewood collection for bare sustenance is leading to the removal of vegetation cover and encouraging soil loss. (Refer to 5.1.6: Depletion of forest.) In the absence of firewood, the rural population in India is burning 40 per cent of cowdung to cook food. The disparity in the energy consumption of different human societies indicates that 'the mechanisms governing the use of resources operate to the advantage of richer nations'.[3]

Possible ways

(a) Need for new orientation towards energy use

The critical position of fossil fuels calls for a new orientation of the present set-up of industrialized societies towards alternative sources of energy which are renewable.

(b) Harnessing solar energy

Sunlight, water and air are renewable sources of energy. The continuous input of energy from the sun is 167,000 times greater than the current consumption. Many countries now are undertaking experiments for harnessing the solar energy for industrial and domestic purposes. Roof panels to capture solar energy, solar cookers and solar batteries are being used in field testing. What is needed is a breakthrough on a massive scale to make manufacturers and householders independent of all other sources of energy. Especially in tropical countries like India where sunlight is available in plenty almost throughout the year, the use of solar cookers will be found profitable in the long run.

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1. Unesco, The Teacher's Study Guide on the Biology of Human Population, Asia, Paris, Unesco, 1975 (p. 112).
2. Ibid. (pp. 110-111).
3. Unesco. Education and the challenge of environmental problems. Paris, Unesco, 10 August 1977 (UNESCO/ENVED 4) (para. 14).

(c) Harnessing water, wind and tidal power

Presently, water power is widely in use all over the world. In Asia water harnessed energy (hydroelectricity) is produced in every country, but there are additional possibilities. There is scope for further exploitation. Tidal power is exploited today in France to produce electricity. India and other countries with a coastline can explore suitable sites for the utilization of this source. Watermills are operated using the swift-flowing waters of mountain streams in Himachal Pradesh to crush wheat grains into flour. Windmills are used in Rajasthan to draw subsoil water for irrigation. The American Aeronautics and Space Administration has designed a rooftop windmill that could give light, heat and power to every home. The time is ripe for taking steps to tame the destructive force of air currents (cyclones, typhoons, fierce gales) for constructive uses.

(d) Biogas

The practice of using the dung of domestic animals as fuel in the absence of firewood by the rural population in many countries should be discouraged as it interferes in the recycling process to replenish the nutrients withdrawn from the soil. Presently in India biogas, usually gobar (cowdung) gas, is being popularized as an alternative source of energy. It has two advantages. Firstly, it would make available the fuel component and relieve pressure on wood supply, secondly, the sludge (left-over material after gas production) which is qualitatively a better manure would be available to the soil. Its universal application will help solve the twin problems of fuel and organic manure.

(e) Fuelwood need of India and possible supply

The National Commission of Agriculture (1976) has estimated the demand of firewood in India at 225 million cubic metres in the year 2000 on the basis of per capita annual consumption of firewood at 0.24 cubic metres. The Chief Conservator of Forests, Madhya Pradesh, estimated the demand in the year 2000 at 370 million cubic metres (at the rate of 0.4 cubic metres per capita annual consumption). By the year 2025, consumption demand would be 700 million cubic metres. Presently, India cannot devote more than 15 million hectares of forest land to the production of fuelwood. Out of 43 million hectares of currently barren and wasteland, 30 million hectares can be motilized for fuelwood plantation. As a maximum of 10 cubic metres per hectare per annum can be produced using the most efficient technology, a target of total national production of 450 million cubic metres can be achieved.[1] Social forestry may be adopted by the rural communities to relieve pressure on fuelwood.

(f) Alley cropping towards solution of rural fuel problem

Alley cropping, currently being developed at the International Institute of Tropical Agriculture (IITA), at Ibadan, Nigeria, Africa, may solve the rural fuel problem. It combines organic fertiliser agroforestry, mulching and biological nitrogen fixation. In alley cropping, food crops are grown between fast-growing leguminous trees or shrubs (such as Leucaena) in rows 4 to 6 metres apart. To avoid competition with the crops in the growing seasons the leguminous trees are kept cut and pruned while the nitrogen-rich leaves and twigs are used for mulching, and the larger branches are used as fuel or poles. In the dry season the trees are allowed to recover and draw nutrients from the deeper soil. The barren soil can also benefit from the system.

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[1] J.B. Lal, 'A rational approach to forest management', The Amrit Bazaar Patrika, Calcutta, 21 July 1982.

(g) Change of food habits for reduction of fuel need

Consumption of 25 per cent of foods in the raw or germinated forms will reduce the amount of fuel consumption. Besides, the germination will enhance the nutritive value of food.

Check yourself

1. List the different sources from which you derive your energy.

2. What are the main sources of energy of the local community? List the sources and their use.

3. Distinguish between (a) the commercial and the non-commercial uses of energy; (b) the renewable and the non-renewable sources of energy.

4. What problems are faced by the local community so far as the fuelwood problem is concerned?

5. How can you solve the problems of fuelwood in your community?

6. In your opinion which of the following ways are preferable to solve energy problems in the locality (i) immediately and (ii) in the long run:

   (a) social forestry (growing trees in barren lands of the locality);

   (b) installing gobar gas plants;

   (c) adopting alley cropping;

   (d) using solar cookers;

   (e) windmills;

   (f) watermills.

5.1.2 Our air resources

The problems

(a) The atmosphere

The atmosphere surrounds our globe like a transparent mantle. It extends into space beyond 1,000 km. The atmospheric pressure (the weight of the atmosphere per unit area) at the sea level is equal to 76 cm of mercury, i.e., 1 x 76 x 13.6 or 1,033.5 gms/cm^2. From this we can have an idea about the total weight of the atmosphere. The surface area of the earth being 5.1 x 10^{18}cm^2, the total weight of the atmosphere would roughly measure 5 x 10^{21} gms. The pressure data of the atmosphere at different altitudes indicate that the higher the altitude, the lesser is the density of air.

Altitudinally, the atmosphere is made up of several layers. Nearest the earth surface is troposphere which extends 6 to 8 km from the equator to the pole. Most of the air of the atmosphere is present in this layer. This is the layer where clouds form, weather pattern changes, and temperature decreases with altitude. Beyond the troposphere is the statosphere which extends up to 80 km. In this layer the air is thinner, the temperature is constant at all levels and there is no turbulence. In this turbulent-free stratospheric layer jet planes fly above clouds and wind. The thinness of air at the upper levels limits the flight up to about 25 km. The zone of the stratosphere between 30 to 50 km is characterized by the ozone layer. Ozone is formed as a result of the action of ultra-violet radiation from the sun on atmospheric oxygen. Further, ozone absorbs ultra-violet radiation and protects the living world from its fatal effects. Above the stratosphere is the ionosphere. It contains a large number of ions and free electons which result from the bombardment of short-wave solar radiation on atoms. This ionised layer extends upwards hundreds of kilometres. Not only does it absorb the strong rays of the sun, but it also starts burning the falling meteors and protects the earth. It also reflects back radio waves signalled from the earth and makes long-distance radio communication possible. The artificial satellites launched from different earth stations hover around the earth at different heights within this sphere.

In the atmosphere there is vertical variation in the composition of air. It is uniform up to 80 km and heterogeneous beyond. In the lower atmosphere 99 per cent of air in volume is constituted of nitrogen (78 per cent) and oxygen (21 per cent). Other constituents include argon, carbon dioxide, neon, helium, krypton, xenon, hydrogen, methane, nitrous oxide and ozone. Water vapour is a variable constituent of air, its concentration being dependent upon the radiant energy of the sun. The concentration range may be from almost 0 to 4 per cent. Carbox dioxide (0.3 per cent) and ozone (0.1×10^{-5} per cent) also vary in their concentration. These three variable constituents of air are very important from the meteriological point of view.

(b) Activities of man and disturbance in the cyclic balance of gases

Increase of carbon dioxide

The amount of carbox dioxide released to the atmosphere due to respiration and decay of organisms is balanced by its withdrawal during photosynthesis by green plants. An excessive amount of carbon dioxide is released by burning fossil fuels. Annually, 6,000 million tons of carbon dioxide is released by burning these fuels in homes, factories and vehicles.[1] As a consequence, the concentration of carbon dioxide in the atmosphere is increasing. Carbon dioxide, being transparent to light in the visible range and opaque to long infra-red 'heat waves' in the spectrum, traps the latter which is radiated back from the earth. It has been estimated that during the last three quarters of this century the concentration of carbon dioxide in the air has been raised from 290 ppm (parts per million) to 330 ppm.[2] It is assumed that it must have led to a rise in the average temperature of the atmosphere to some extent. As climatic balance is very sensitive to temperature even a small change in temperature can have a very drastic effect, but actual occurrence of such climatic changes probably has not been demonstrated.

Change in the nitrogen balance

Industrial fixation of nitrogen to produce fertilizers is now adding to the rate of nitrogen fixation. This is bringing about a change in the nitrogen balance with unknown effects. But it is resulting in the increase of concentration of nitrate especially in human water supplies, which definitely has harmful consequences. In future, as the population grows, the demand of nitrogen fertilizer will go on increasing. The world production has increased from 30.1 million tons in

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1. Unesco. Teacher's study guide on the biology of human population. Asia; Paris; Unesco, 1975 (Fig. 52, p. 135).
2. Ibid. (p. 126).

1969-1970 to 59.7 million tons in 1979-1980, i.e., 100 per cent increase in one decade.[1]

Acid precipitation

Oxides of sulphur and nitrogen released from anthropogenic sources are precursors of acidity of precipitation. These gases, released into the atmosphere, undergo physico-chemical transformation, in the presence of sunlight and water (rain), to form acid rain. The acid rain on earth has deleterious effects on soil, rivers and buildings as well as on living systems.

Ozone depletion

Nitric oxide (NO) and chlorine (Cl) revert ozone back to oxygen following basic chemical reactions:

$$
\begin{array}{rcl}
NO + O_3 & \longrightarrow & NO_2 + O_2 \\
NO_2 + O & \longrightarrow & NO + O_2 \\
\hline
O + O_3 & \longrightarrow & 2\ O_2 \\
Cl + O_3 & \longrightarrow & Cl\ O + O_2 \\
ClO + O & \longrightarrow & Cl\ O + O_2 \\
\hline
O + O_3 & \longrightarrow & 2\ O_2 \\
\hline
\end{array}
$$

Both these gases originate from natural and anthropogenic sources. Volcanic eruptions give our chlorine. Solar particles, particularly after solar flares, produce nitric oxide through impact dissociation of atmospheric nitrogen. Variation in ozone is caused by ultra-violet radiation variation resulting from solar cyclic changes. So there is a natural production-destruction cycle and balance. But stratosphere loading of chlorine and nitric oxide from anthropogenic sources, especially within the last two decades, has added to the 'hazards to our ozone environment' (Mitra 1979).[2] Nitric oxide is emitted by supersonic aircarft and it is injected by nuclear explosions. Besides, nitrogenous fertilizers give out nitrous oxide (N_2O) which ultimately gets converted into nitric oxide in the stratosphere. Chlorine arises from photo-dissociation of industrial chlorofluoromethane. This heavy loading of stratosphere with nitric oxide and chlorine has raised the problem of ozone depletion, which has severe consequences to life on the earth.

(c) Atmospheric pollution

Atmospheric pollution is caused by the presence of contaminants whose amount, nature and duration become injurious to man, animal, plant or property. Contaminants may be gaseous or particulate which may arise from natural or anthropogenic sources (Table 1).

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1. Fertiliser statistics, 1980-1981; New Delhi, The Fertiliser Association of India, 1981; (p. III 4 and III 5).
2. A.P. Mitra, Hazards to our ozone environment, Society and Science, A Journal of Nehru Centre, N. Delhi, Vol. 2, No. 1, January/March 1979.

Table 1: Sources and pollutants

Sources	Pollutants	
	Gaseous	Particulate
1. Natural		
Volcanic eruptions	Chlorine	Dust
Ocean spray		Salt
Sand and dust storm		Dust
Vegetation	Gases (H_2S, hydrocarbons)	Bacteria, moulds, spores, pollen-grains
Forest fire	Gases	Smoke
2. Anthropogenic		
Vehicles, aircraft, ships	CO, oxides of nitrogen and sulphur, hydrocarbons	Smoke, lead particles
Thermal power plants (coal-fired)	Sulphur oxides (SO_2, SO_3) Oxides of nitrogen (NO, NO_2) Carbon monoxides (CO) Hydrocarbons (Hc)	Coal ash
Stationary combustion	SO_2, NO_2	Fly-ash, smoke
Oil refineries	SO_2, CO, hydrocarbons	Smoke
Steel plants, cement plants, ceramic factories		Dust
Chemical plants	H_2S, CO, SO_2 Other undesirable and obnoxious gases	
Agricultural		
Insecticides, pesticides		Dusts, sprays, fumes
Fertilizers	N_2O, fluorides	Particulates
Grain mills		Particulates
Nuclear explosion	NO	Radioactive fallout

The important gaseous pollutants are carbon monoxide, hydrocarbons, hydrogen sulphide, nitrogen oxide, sulphur-oxides, and ozone. Over 60 per cent by weight of the total pollution released into the atmosphere arises from the exhaust from transportation (vehicles, aircraft, ships using combustion engines).[1] Other major sources of air pollution are domestic heating, electric power generation, refuse burning and industrial fuel consumption and process emissions.

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[1] J.K. Singh. 'Transportation Pollution Control for Clean Air'. Proceedings of the symposium on air pollution control, Vol. I, New Delhi, Indian Association for Air Pollution Control, 1983 (pp. 5-6).

In the U.S.A. 142 million tons of pollutants per year are given off to the air, out of which 86 million tons are contributed by motor vehicles, 20 million tons by industries, 8 million tons by heating, and 5 million tons by refuse disposal. The automobiles contribute 63 per cent of the total CO emissions, 52 per cent of the hydrocarbons and 39 per cent of the oxides of nitrogen.[1]

The level of pollution due to the automobile exhaust in major cities of the world, both in the developed and developing countries, is quite comparable. Carbon monoxide percentage of air pollution in London, Chicago, Washington, New York and Calcutta are 58, 46, 41, 27 and 35 ppm respectively.[1]

Lime kiln operations, charcoal-making, burning of wood, bush fires, etc., are the main sources of air pollution in underdeveloped areas.

In high population density areas of technological societies, air pollution has led to the decreased breathing capacity in children, decreased physical performance of the adults, incidence of illness especially respiratory diseases such as chronic bronchitis, bronchial asthma and lung cancer, and even the death of many people. Air pollution affects visibility. Fluorides released from phosphate fertilizer plants and aluminium plants affect the health of cattle (periodic diarrhoea, lameness, worn teeth, loss of weight). Vegetation is affected by pollutants like sulphur dioxide, nitrogen oxides, fluorides and ozone leading to losses in the crop yield. Air pollutants corrode, tarnish, soil, erode, crack, weaken, discolour several varieties of material. Sulphur dioxide can cause corrosion of metal, marble, limestone. Ozone damages rubber goods.

Possible ways of reducing pollution

It is essential to undertake suitable measures to control air pollution. Steps may be taken (a) to determine the major sources of air pollution; (b) to develop air quality standards using environmental, health and economic criteria; (c) to enact laws to regulate and enforce air quality standards; (d) to build infrastructures to detect and locate increases of air pollutants; (e) to adopt preventive measures such as: constant surveying and monitoring of pollution level in ambient air; using fuels that emit less obnoxious pollutants; using increasingly public mass transport and curtailing private vehicles; ensuring proper disposal of waste and enforcing the use of air pollution control devices such as electric precipitators, smoke meters, incinerators, catalytic converters, etc., in the locations of the sources of pollution, intensifying the planting of trees in urbanized and industrialized areas to compensate for the oxygen loss. (It requires ten trees to produce the daily requirement of oxygen to burn one gallon of petrol.)

Check yourself

1. Give any two examples of the following:

   (a) components of air with non-variable concentrations;

   (b) components of air with variable concentrations;

   (c) components of air with intimate relations with the living beings.

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[1] M.M. Tamakuwala. 'Auto air pollution - its sources, effects and control', Proceedings of Symposium on Air Pollution Control, New Delhi. Ind. Asson. Air Pollution Control, 1983, p. 157.

2. Justify the following statements:

   (a) The rapid growth of industrialization is leading to an increase in the concentration of carbon dioxide in the atmosphere.

   (b) The increase of carbon dioxide concentration in the air is slowly raising the average temperature of the atmosphere.

   (c) The human water supply is affected by nitrates due to fertilizer production and use.

3. Link the items of column (i) with those of column (ii).

(i) Sources	(ii) Pollutants
(a) Aluminium refineries	(l) Dust
(b) Oil refineries	(m) Carbon monoxide
(c) Motor vehicle	(n) Sulphur dioxide
(d) Cement factory	(o) Fluoride

4. Make a survey of your locality and identify the major sources of air pollution and devise a plan of measures you could take to prevent and control air pollution.

5.1.3 Our water resources

The problems

(a) Available water for human use in the hydrosphere

As air composes the atmosphere so water composes the hydrosphere of our globe. The total volume of water present in the hydrosphere is about 1,360 million cubic kilometres (km^3). Out of this, oceans contain 97.2 per cent of the water (1,322 million km^3); ice caps and glaciers, 2.15 per cent.[1] The rest is distributed in ice caps and glaciers, lakes, rivers, streams, subsurface water and water vapour.

In the hydrologic cycle of rainfall, runoff and evaporation of water 140 million square kilometres of land surface of the globe receives annually 94,900 km^3 water as rainfall.[2] Out of this 58,400 km^3 of water evaporates into the atmosphere and the rest 36,500 km^3 of water is accounted for by surface runoff.

Available water for human use

Man is dependent upon water which is available in rivers, streams, fresh water lakes and subsurface water present in upper layers. The sources of water for various human uses may occasionally include direct rainfall and desalination, but are constituted mainly of subsurface (ground) water and surface flow. This usable water is only about 0.3 per cent (4,080,000 km^3) of the total volume of water in the hydrosphere. Man has to share this usable water with the plant and the animal world.

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[1] Unesco. Teacher's study guide on the biology of human population, Asia; Paris; Unesco, 1975 (p. 140, Table 20).

[2] Paul R. Ehrlich; Anne H. Ehrlich. Population, resources, environment, San Francisco, W.H. Freeman & Company, 1972, p. 76.

Distribution of usable water

There is great variation in the distribution of usable water over the earth ranging from scanty supply in the deserts to extremely wet humid areas like Assam. More than 55 per cent of the world's population lives in Asia. The continent covers about 15 per cent of the global area and contains about 20 per cent of its runoff (6,663 km^3) and one-third of its potential hydropower. The largest share of mean annual runoff in the Asian region is possessed by Indonesia with 1,940 km^3 followed by India with 1,508 km^3.[1] The mean annual rainfall exceeds 100 cm over most of India and South-East Asia, varying from 13 cm in Thar desert to as much as 1,080 cm in Cherrapunji. Further, in this region most of the rainfall is seasonal and occurs in the monsoon resulting in frequent destructive floods along the river courses and delta areas. The erratic behaviour of the monsoon may cause flood and drought side by side in the same region. In places like Port Blair, surrounded by seas, drinking water is as scarce as in the Rajasthan desert. Though different human societies, like various biocommunities, have adapted to various climates including limited rainfall, yet the availability of usable water plays a decisive role as a limiting factor.

(b) Water needs of man

Adequate water supply of standard quality is essential to meet the individual, domestic, industrial and agricultural needs of man.

Individual needs

A human being needs daily approximately two litres of water to compensate for its loss from the body through urine (1,000 ml), breath and sweat (900 ml) and faeces (100 ml).[2] He fulfils this need by drinking and through food.

Domestic needs

To live a standard healthful life a household of five persons needs daily a minimum 500 litres of water for drinking, cooking, bathing, washing and watering potted plants. In addition, man has to find water to meet the needs of domestic animals, to water lawns or gardens and to wash vehicles for personal use. These are variable factors.

The potable water supply at present is very inadequate. (See Sub-Unit 5.3.1.)

Industrial needs

The industrial and commercial needs of water are tremendous. The production of one ton of cotton fabric needs 250 m^3 water; man-made fabric, 2,500 to 5,000 m^3; woollen fabric, 580 m^3; paper, 150 m^3; paper board, 57 m^3; cane sugar, 4 m^3; oil refining, 18 m^3; steel, 250 m^3; soda, 320 m^3; sulphate, 240 m^3; ammonia, 1,000 m^3; synthetic rubber, 2,000 m^3; nickel, 4,000 m^3.[3] One can visualize what a large amount of water is required to meet the world production of these and other items. Further, since industrialization is expanding in the developing countries, the demand for water is also increasing proportionately. Total intake of 400 km^3 of water is now required annually by the industrial world. Already factories and mills in a number of industrial regions in Europe and North America are threatened with water shortage.

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[1] United Nations. Water resources series No. 40, 1971, p. 34.

[2] Unesco. Teacher's study guide on the biology of human population (Asia), Paris, Unesco, 1975 (p. 166).

[3] (a) S.T. Powel and H.E. Bacon. Journal of the American Water Works Association, August 1950. (From Unesco. Teacher's study guide on the biology of human population (Asia). Paris, 1975, p. 168).
(b) M.L. Lvovich quoted by S. Supkar in Water Resources Law. Sambalpur, University Journal, Sambalpur, 1974, Vols. VI and VII, p. 14).

Agricultural needs

Agricultural needs for water are much more than those of domestic and industrial needs. To enhance the productivity from limited arable land to meet the ever increasing needs of growing populations, proper irrigation of agricultural land at the proper time is essential. Out of 298.2 million hectares of cultivated area in the Asian region, 76.2 million are irrigated utilizing 11.5 per cent (767 km^3) of runoff. It will be necessary, as per Indicative World Plan (I.W.P.), to expand irrigated harvested areas to 136 million by 1990, which will necessitate utilization of about 20.48 per cent (1,359 km^3) of runoff. In India, 28.5 per cent (10 km^3) of runoff is utilized to irrigate 42.9 million hectares out of 170 million hectares of the cultivated area. By 1990 India would need to utilize 51 per cent (770 km^3) of runoff to meet the irrigation requirement of 77.1 million hectares to feed her growing million.[1]

Needs of water for power generation

Refer to Sub-unit 5.1.1 'Our energy resource' where the need of water for power generation is discussed.

(c) Deterioration in the quality of water through physical, chemical and bacteriological pollution

The problem before human societies is how to make available enough water to satisfy the domestic, industrial and agricultural needs. More important than the supply of water is the quality of water which is supplied. It is rare now to get in nature water which is uncontaminated. There are places blessed with water resources of very good quality such as spring water and deep groundwater. But many sources are contaminated by natural impurities, some of which may be health hazards; some may seriously affect soil, and some industries. Deterioration of the quality of water resources has been going on for centuries. Cities on the banks of rivers are discharging large volumes of sewage into the rivers making the water unfit for drinking, bathing and other purposes. Present urban and rural water supply systems produce 65 km^3 of sewage annually of which 5 km^3 is discharged into the sea. Out of the remaining 60 km^3 of sewage which is discharged into the rivers 50 per cent is untreated. 30 km^3 of untreated sewage would need 400 km^3 of clean or treated water, and treated sewage, 200 km^3 of clean water to be rendered reasonably harmless. So more than 600 km^3 of clean water is needed to purify the total urban and rural sewage. With the increase of population the amount of sewage will increase. The industrial world in the 1970s was dumping 160 km^3 of waste water into rivers, polluting 4,000 km^3 of river water. This is about 10 per cent of the world's river flow and 25 per cent of the rivers in industrialized countries.[2] A manifold increase in industrial growth due to industrialization is expected to take place in developing countries. As a result, it is estimated that the world industries by the turn of the century will be releasing 24,000 km^3 of industrial waste water into rivers annually polluting heavily the whole annual runoff. Most of the sources of water - rivers, canals, open and unprotected wells or just mudholes in the ground - in the rural areas of the developing countries are contaminated with

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1. United Nations. Water resources series No. 40, 1971, p. 35.
2. Shraddhakar Supkar. Water Resources Law. Sambalpur University Journal, Sambalpur, 1974; Vols. VI and VII (pp. 13-16).

harmful organisms which causes five categories of water-related diseases:[1] (i) water-borne diseases (cholera, typhoid, infections, hepatitis); (ii) water-washed diseases (scabies, yaws, leprosy, typhus, paratyphoid fever, conjunctivitis and trachoma); (iii) water-based diseases (caused by aquatic organisms such as guinea worms and urinary and rectal infections); (iv) diseases with water-related insect vectors (yellow fever, malaria, sleeping sickness and other infectious viral fevers); (v) diseases related to faecal disposal.

Pesticide and fertilizer residues are washed down to rivers and seas deteriorating water quality.

Natural impurities of the water resources as well as alarming deterioration in the quality of water through physical, chemical and bacteriological pollutions resulting from human activities pose problems which merit special attention.

Possible ways

Efficient water management should fulfil the following conditions:

potable water supply in adequate amount for both rural and urban populations;

adequate water supply of standard quality to industries;

optimal water supply of standard quality to agriculture in time minimizing wastage of water, soil and plant nutrients and maximizing crop yields, providing proper drainage and preventing water logging and salination;

full exploitation of potential resources for power generation;

prevention of wastage and pollution;

measures to check depletion of resources;

purification of water and pollution control.

Check yourself

1. To what extent do irrigation projects provide for the delivery of water to individual farms in your locality? Do farmers readily accept and utilize the water provided?

2. What are the water resources in your community? What is the quality of water you use?

3. Does your area experience flood and/or drought? What are your suggestions to solve the problem without depleting water resources?

4. How can you keep your water resources uncontaminated?

5. How much water do you need daily and how much do you get?

6. Write short notes on:

   (a) hydrologic cycle;

   (b) domestic use of water;

   (c) industrial pollution.

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[1] UNICEF. Children, Water and UNICEF, New York City. Code 381-78-30M (p. 6).

5.1.4 Our soil resources

The problems

(a) The soil

The soil is at the surface of the land resulting from the twin operations of the decomposition of rock and the decay of organisms. The natural soil originates as pure mineral material. In due course the decaying of organisms which live either within the developing soil or on its surface, gives rise to varying amounts of organic materials (humus) which enter into the composition of the soil. Water and air fill the porous spaces between the soil particles (interstices) which are the result of irregularities in the shape and size of the particles. Large spaces facilitate drainage and aeration while small spaces enhance water retention.

The soil is a complex system consisting of three intermixed phases: solid, liquid and gaseous. The solid phase occupies 50 per cent of the soil volume. The remaining 50 per cent of the soil volume is occupied by the liquid and gaseous phases which have an inverse relationship between them, i.e. when volume of water in the soil increases (as after rain or irrigation) the volume of air in the soil decreases, and when volume of water decreases (as after drainage, evaporation or transpiration) the volume of air volume increases. The solid phase is composed of inorganic soil particles as well as materials derived from the decomposition of plant and animal residues; the liquid phase is composed of water containing a variety of mineral (inorganic) and organic substances in solution; the gaseous phase is composed of air with relatively high concentrations of carbon dioxide resulting from the activities of the micro-flora and micro-fauna as well as plant roots.

The properties of the soil depend upon five soil forming factors: parent materials (minerological composition of rocks), time (age), relief (topography), climate and biota (vegetation, organisms, man). Parental material, relief and time are passive factors while climate and biota are active factors. The relative proportion of soil particles of varying sizes (sand, silt and clay) and their arrangement determine the various physical properties of the soil such as texture, structure, bulk, density, poresity, water retentivity and water movement. The salt content, pH, available N,P,K and other inorganic and organic nutrients in the soil determine the chemical properties of the soil. The productive potential of the soil depends upon its physical and chemical properties.

The mineral elements found in the soil, which are essential for normal plant growth, are 16 in number. They are listed in the table below (Table 2).

The soil also contains sodium, iodine and cobalt which are essential to animals. Besides, it also contains toxic elements such as selenium, arsenic, molybdenum, fluorine, aluminium, nickel, etc.

Physical and chemical analyses of soil can indicate conditions such as mechanical impedence, low water and nutrient retentivity, excessive and low permeability, acidity, alkalinity and lack of nutrients which limit crop production. Soil management practices such as deep tillage, compaction, manure and fertilizer addition, lime and gypsum application can be suitably undertaken to improve soil productivity.

(b) Soil cover of the globe

Many regions of the world constituting about 20 per cent of the total land area are without any soil cover. Almost all of the Antarctic is soil-less. Permafrost regions of high mountain peaks also are soil-less. Soil-less areas are also found in the tropics.

Table 2: Essential plant nutrients found in soil

Nutrients obtained from air and water	Nutrients obtained from solid phase soil: Macronutrients (required in large amounts)		Micronutrients (required in small amounts)
	Primary	Secondary	
Carbon	Nitrogen (N)	Calcium	Iron
Hydrogen	Phosphorus (P)	Magnesium	Magnesium
Oxygen	Potassium (K)	Sulphur	Copper
			Zinc
			Boron
			Molybdenum
			Chlorine

(c) Soil degradation

Soil degradation is taking place on an alarmingly large scale throughout the world due to mismanagement by man. Problems such as erosion, waterlogging, salination, desertification, and shifting cultivation are continuing rapidly and widely. It is estimated that, if the current rates of land degradation continue, about one-third of the world's arable land will be destroyed by the turn of the century.[1] Vast soil-rich areas are also being encroached upon due to the ever-growing developmental process.

(d) Soil erosion

The soil is eroded by water, wind, ocean waves or glaciers. Mismanagement of the soil by man such as deforestation, overgrazing, overcropping or inappropriate ploughing, facilitates accelerated erosion by water and wind. Experts point out that erosion can take place in wet as well as in arid zones, whether agricultural practices are primitive or sophisticated. Deforestation exposes the soil to be washed away by runoff water, and, especially on hill and mountain slopes, the amount and rapidity of the resulting soil erosion become alarming. Erosion by water is manifested in four forms: surface erosion, finger gullying, gully erosion and stream erosion.

The soil is kept intact by the grass sod, which serves as an excellent binding material. The breaking down of that sod by the plough loosens the soil and increases the danger of soil removal by running water and high winds. Wherever men have tilled or grazed slopes or semi-arid soils accelerated erosion has followed.

Erosion is widespread in culturally diverse areas like India, China, Australia, South African nature reserves, Spain, USSR, U.S.A. and Central America.

During the last century erosion on a vast scale has taken place in such places as America and China. Presently, erosion is stripping away America's fertile soil at the alarming rate of over one million acres per year.[1] In India deforestation and overgrazing have been the causes of erosion. The arid region of north west India, covering a million hectares, of Gujarat, Rajastjan and Punjab, is subject to intense wind erosion. Experts have estimated that in India at least 40,000 hectares of our soil annually is permanently lost to the cultivation[2] and a much larger area is rendered less productive by the ravages of water and wind erosion.

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[1] IUCN. Against the grain, The Unesco Courier, Paris, Unesco. May 1980, 33rd year (p. 10).

Desertification

The removal of vegetation cover leads to desertification. Most of the world's deserts are man-made. The Rajasthan desert covering an area of about 207,200 km^2 and extending over to Punjab, Haryana and Gujarat is largely man made and is spreading as a result of the exploitation of limited natural resources by overgrazing of pastures, cutting of forests and poor cultivation - all contributing to wind erosion.

About 7.3 million hectares of the Rajasthan desert is covered by sand dunes which shift frequently and bring about reduction in agricultural productivity and hamper natural regeneration of the vegetation.

Shifting cultivation

Shifting cultivation is still very widespread in the tropical regions of Asia, America, Africa, and Oceania. It is practised by more than 200,000,000 people occupying 30,000,000 km^2 of tropical forests.[3] In the north east hill region of India the practice is called jhum which is very common. The jhum cycle, the time interval before the same site is cropped again, has been reduced in recent times from a long 20-30 years to a short four to five years threatening soil stability.

Intervention of a long fallow period (more than 20 years) brings about restoration of soil fertility. Further, as shifting cultivation is based usually on a single species of crop plant a heavy depletion of certain minerals occurs. The system does not support a large population.

Salination

Soluble salt contamination of the soil may be primary, natural or secondary, often man made. As land use intensifies and water becomes more limiting, salination increases devastatingly. Mismanagement of agriculture induces secondary salination of the soil. Salinity is widespread and occurs practically in every country. A third of the world's land area is semi-arid or arid, and half of that area has highly saline soils.

In several areas of the Indo-Gangetic Plain salts accumulate in the surface layer of the soil due to inadequate drainage. During the summer months, as evaporation of moisture takes place from the soil, salts are brought up to the surface, by capillary action, forming a white crust. The total area of such land in the country has been estimated at 6 million hectares. Most of these areas have been lying barren for a long time. In Punjab about 6,000 to 8,000 hectares of good land is becoming barren every year due to salination.

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1. Andre van Dan. What food for everybody. Development and Co-operation (D&C). Bonn. The German Foundation for International Development, D&C 6/81 (Nov.-Dec.), 1981 (p. 10).
2. S.P. Raychandhury. Land and Soil, New Delhi, National Book Trust India, 1969 (p. 81).
3. IUCN. Against the grain, The Unesco Courier, Paris, Unesco, 33rd year, May 1980 (p. 13).

Waterlogging

Irrigation from major works generally lead to the rise of the water table, culminating in waterlogging. The Indus and its tributaries water one-eighth of the world's irrigated area. Eighteen per cent of the gross area shown in the Indus plain, i.e. two million hectares, is seriously damaged by salinity and waterlogging. The damage is increasing at the rate of 20,000 to 30,000 hectares per year.[1] In India, Punjab is worst affected by waterlogging.

Soil loss due to developmental processes

Areas with good productive soil such as forests, grasslands and croplands are lost due to mining, dam construction, road building, the laying of rail lines, the establishment of plant, and factories, urban encroachment and random growth of human settlements.

In developed countries annually at least 3,000 km^2 of prime agricultural land is submerged under urban sprawl. Within the decade 1960-1970, Japan lost 7.3 per cent of its agricultural land to roads and buildings and European countries lost from 1.5 per cent (Norway) to 4.3 per cent (Netherlands).[2]

Possible ways

Proper land management is essential to control degradation and maintain, restore and improve the soil.

Control of both natural and man-made erosion is the major aspect of proper land management.

In nature the vegetation cover inhibits erosion. Roots hold soil together. Leaves intercept rain and break the impact of water on the soil. Plants shield the soil surface from wind and solar energy. They also provide humus. Humus and the reduced impact of water on the soil maintain the surface porosity of the soil. Percolation is avoided and runoff limited. The rate of drying of the soil is inhibited, so also the movement of the soil particles.

Erosion caused by floods can be stemmed by small dams that will then release the accumulated water in dry seasons. Accelerated erosion can be controlled by contour tillage, terracing, gully reclamation, strip cultivation and windbreaks.

It is essential to replace shifting cultivation by other systems. Shifting cultivation can be replaced by other methods, such as crop rotation and mixed cropping which will improve soil fertility, increase productivity and support a large population.

Salinity can be removed if the soils are irrigated with the provision of adequate drainage. Saline soil is improved by leaching for which extra water is added to the field and allowed to soak through the soil and drain away. If natural drains are inadequate, artificial drains should be built. Extra water may sometimes be leached into a well from which water can be removed by pumping. Leaching is effective when the groundwater table is not close to the surface.

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1. Watter H. Pawley. Possibilities of increasing world food production, FAO, FFHC Basic Study No. 10, Rome, 1967 (p. 68).
2. IUCN. Against the grain. The Unesco Courier, Paris, Unesco, 3rd year, May 1980, p. 10.

Besides leaching the soil, additions of specific chemical amendments and employment of green manuring can improve alkaline and acidic saline soils.

Water-logged lands can be reclaimed by surface drains especially in humid areas with heavy and compact soils or underground drains.

For the stabilization of sand dunes the employment of the technique of mulching the area with different plant species putting them in small squares can serve as an effective barrier to the moving sand.

In short efficient soil management requires adoption of the following measures:

restoration of the vegetation cover in order to check erosive action of wind and water;

encouragement for the growth of grass and forests on lands which have become too arid and poor to support cultivated plants;

utilization of the water resources properly, adequate and timely supply of water for irrigation with the provision of adequate drainage;

mechanical and engineering measures such as contour tillage, terracing, gully reclamation, strip cultivation, shelter belt, dams as required;

use of soil amendments such as lime, gypsum, etc., to saline, alkaline and acid soils as required;

use of chemical fertilizers with care and discretion without disturbing the biological processes of soil formation and soil life cycles, and application of green manuring, the use of legumes, crop rotation, animal manuring and the use of human waste.

Check yourself

1. Define: (a) erosion; (b) jhum; (c) salinity.

2. Write short notes on: (a) Chipko movement; (b) water logging; (c) soil amendment.

3. What type of problems regarding the soil occur in your locality? What may be the causes according to your understanding? What suggestions can you give to solve the problem?

5.1.5 Our mineral resources

The problems

(a) Definition

The non-living, naturally occurring chemical compounds, of both organic and inorganic origin and concentrated in the earth's crust constitute our mineral resources. Geographically localized mineral deposits which are economically exploitable are called ores.

The earth's crust is composed of about 88 elements. Ninety-nine per cent of the earth's crust is composed of oxygen, silicon, iron, magnesium, aluminium, calcium, nickel, sodium, potassium and titanium. All other elements together form 1 per cent. Besides the earth's crust, the oceans and the atmosphere are also potential sources of some elements.

(b) Variation in mineral distribution

There are great variations in the distribution of minerals in the earth's crust and in degrees in which these elements are concentrated in minerals. Asia is rich in tin, tungsten and manganese. Africa is poor in tungsten but possesses most of the world's gold, chromium and cobalt. North America is rich in molybdenum but poor in tin and manganese. Europe is in exclusive possession of mercury.

(c) Role of minerals

Man's use of minerals has shaped his destiny throughout the ages starting from the Stone Age 300,000 years ago when he used crudest flint implements to the present technological age when he uses minerals in precision tools and in earth-orbiting artificial satellites. Minerals have become indispensable to human life. Their use can be seen in all spheres of human life. The use of some minerals can be seen from Table 3.

Table 3: Some important minerals and some of their uses[+]

Minerals	Uses
I. Fuels	
1. Conventional fuels	
Bituminous and anthracite coal	Direct fuel, thermal electric gas, chemicals, fertilizers
Lignite	Electricity, gas, chemicals
Petroleum	Gasoline, other fuels, plastics, fertilizers
Natural gas	Fuel
2. Nuclear fuels	
Uranium	Nuclear bombs, electricity, tinting glass
Thorium	Nuclear bombs, electricity, gas mantles
II. Non-fuel metallic minerals	
3. Ferrous metals	
Iron	Steel
Manganese	Alloy steels, disinfectant

Minerals	Uses
Cobalt	Alloys, catalysts, radiographic, therapeutic
Columbium	Stainless steel, nuclear reactors
Chromium	Metallurgical, refractory, chemical
Molybdenum	Alloy steels
Nickel	Over 3,000 alloys
Tungsten	Alloys and chemicals
Vanadium	Alloys
4. Non-ferrous metals	
Copper	Electrical products, alloys
Lead	Batteries, gasoline, paints, alloys
Tin	Tin plate, solder, chemical
Zinc	Galvanising, solder, die casting, chemical
5. Light metals	
Aluminium	Aircraft, rockets, building materials, electrical wiring, utensils
Magnesium	Structural refractories
Titanium	Pigments, aircraft, alloys
Zirconium	Refractories, ceramics, metals, chemicals
6. Other metals	
Beryllium	Copper alloys, refractories, atom energy field
Gold	Monetary, jewellery, dentistry
Radium	Medical, industrial, radiography
7. Non-metallic minerals	
Asbestos	Insulation, textiles, roofings, glass, ceramics, gasoline, solid propellants

Minerals	Uses
Corundum	Abrasives
Feldspar	Ceramic flux, artificial teeth
Fluorspar	Flux, acid, refrigerants, propellants
Phosphates	Fertilizers, chemicals
Salt	Chemicals, glass, metallurgical
Sulphur	Fertilizers, acid, iron and steel industries

+Source: From Table 1, General classification of selected minerals and some of their uses, McGraw-Hill Encyclopedia of Science and Technology, New York, McGraw-Hill Book Company, Vol. 8, 1966 (p. 461).

(d) The depredation of minerals

The wide range of their uses has caused enormous depredations in the stock of minerals in the accessible parts of the earth. In this depletion of the mineral resources, the wars of the present century have created havoc by consuming and destroying more basic metals and minerals than were consumed during the whole course of human history.

The onset of industrial revolution opened a flood-gate in the utilization of minerals. The findings of the United Nations Survey indicate that during a short span of 115 years from 1855 to 1970 about 16,000 million tons of iron ore was used up, more than half of which was consumed during the last 25 years.[1] World consumption of minerals, both in terms of gross tonnage and per capita basis, is showing an upward trend. Compared with developed countries, the consumption rates of minerals in developing countries, at present are insignificant; but once their exploratory stages are over, consumption rates would rise rapidly in the coming decades. It is estimated that there will be a trebling of the world demand by the end of this century.

The U.S.A., the world's biggest consumer of materials has already turned into a deficit nation from a surplus one for some raw materials. Its demand for most of the manganese, chromium, cobalt, tin, copper and bauxite is met through imports. Its needs for lead, zinc, tungsten, iron and copper are supplemented from outside sources. The alarming depletion of minerals in the world, especially the vanishing reserves of such minerals as lead, tin, zinc, copper, nickel and petroleum and natural gas, have alarmed the geologists and industrial economists.

A few industrialized countries have adequate internal reserves today of coal, iron, copper, aluminium, and fertilizer minerals which are basic to our civilization to meet their current demands. There is danger of exhaustion of platinum, gold, zinc, lead, silver, tin, petroleum and natural gas before the end of this century.

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1. Unesco. Teacher's study guide on the biology of human population (Asia), Paris, Unesco, 1975 (pp. 290 and 293).

India has rich reserves of iron ore, titanium ore, mica and thorium ore, a surplus in bauxite, manganese ore, silica, is self-sufficient in aluminium, antimony, arsenic, coal, gold, uranium, vanadium, but has a deficit in or is devoid of lead, nickel, cobalt, phosphate, platinum, potash, silver, sulphur, tin, tungsten and zinc.[1] Man's spending away of earth's non-replenishable minerals casts a gloom before the coming generation. A big question is how to sustain this civilization of the mineral age.

Possible ways

(a) Conservation measures

Conservation measures, recycling, exploration of the presently inaccessible areas of the earth's crust as well as oceans, disarmament, and substitution are some of the possible ways available for the future.

Discouragement of wasteful designs, reduction in per capita use, keeping a balance between population size and resource demands can be adopted to reduce the depletion of existing resources. But being non-replenishable the minerals cannot last for ever; sooner or later the reserves will be exhausted.

(b) Exploration of inaccessible areas

So far man has been extracting the mineral deposits reserved in the accessible regions of the earth's crust. So modern technology should focus attention on exploring the deeper layers of the crust. Other sources of some minerals are the world's seas which await exploration. Substandard ores that have been untouched can also be refined.

(c) Recycling

Mineral products used by man end as solid waste and they can be recovered by recycling.

(d) Reduction in armaments

A heavy demand on minerals is due to the armaments race. Reduction in this race as well as reduction in defence production will greatly reduce the rate of depletion of minerals.

(e) Substitutes

The tempo of mineral consumption is such that man is already confronted with the problem of replacement of exhausted minerals by non-mineral products like plastics, glass, ceramics, etc. How effective substitutes for the vanished minerals will be is beyond our present grasp today.

Check yourself

1. Define: (a) mineral resources; (b) depletion; (c) substitution.

2. Give two examples each of: (a) non-replenishable materials; (b) replenishable materials; (c) metals; (d) non-metals.

3. Prepare a list of items of mineral products in common use in your community, and write against each a corresponding item of non-mineral origin but of common use.

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[1] Meher D.N. Wadia. Minerals of India. New Delhi, National Book Trust, India, 1969 (pp. 188 and 189).

5.1.6 Our plant resources

The problems

(a) Utility

Plants are the producers and feed the entire world of living organisms. Besides, they provide shelter to the animal kingdom. In addition, plants provide man with fuel, fibre and an ever-increasing number of items needed by the industrial society.

(b) Major biological systems and their distribution

Plants cover almost the entire 14,000 million hectares of land surface of the earth in four major biological systems - forests, grasslands, croplands and deserts - leaving aside the permafrost regions of the poles and mountain peaks and some bare areas of the deserts.

Table 4: Land use 1980 (in 1,000 hectares)

Continent or country	Total area	Land area	Agricultural land	Grassland	Forest land	Other land
World	13,392,148	13,075,248	1,452,215	3,116,685	4,093,547	4,412,801
Africa	3,033,103	2,966,447	181,164	784,265	696,027	1,304,991
N. C. America	2,241,492	2,135,581	271,368	352,132	683,204	828,877
S. America	1,781,851	1,753,454	125,741	449,644	942,630	235,439
Asia	2,757,442	2,676,872	455,022	603,281	545,579	1,072,490
Europe	487,084	472,788	140,949	86,673	154,769	90,397
Oceania	850,956	842,906	76,005	446,490	151,338	179,073
USSR	2,240,220	2,227,200	231,966	373,700	920,000^{+}	701,534
U.S.A.$^{++}$	936,312	912,680	190,624	237,539	284,464	200,053
India^{+++}	328,759	297,319	169,130^{F}	12,000	67,480^{F}	48,709
China^{+++}	959,696	930,496	99,200^{F}	220,000^{F}	116,400	494,896

Source: FAO Production Yearbook 1981

+	Unofficial figure
F	FAO estimate
++	Included in N. C. America total
+++	Included in Asia total

Table 5: Land use 1980 (in percentage)

Continent or country	Total area	Land area	Agricultural land	Grassland	Forest land	Other land
World	100	100	100	100	100	100
Africa	22.64	22.68	12.47	25.16	17.00	29.57
N. C. America	16.73	16.33	18.68	11.29	16.68	18.78
S. America	13.30	13.41	8.65	14.42	23.02	5.33
Asia	29.57	29.46	31.33	18.35	13.32	24,39
Europe	3.63	3.61	9.70	2.78	3.78	2.04
Oceania	6.35	6.44	3.16	14.32	3.69	4.05
USSR	16.73	17.03	15.97	11.99	22.47	15.89
U.S.A.+	6.99	6.98	13.12	7.62	6.94	4.53
India++	2.45	2.27	11.64	0.38	1.65	1.10
China++	7.16	7.11	6.83	7.05	2.84	11.21

Source: Estimated from data in FAO Production Yearbook 1981
+ Included in N. C. America total
++ Included in Asia total

The total world area officially recorded by FAO under land use, as per FAO Production Yearbook 1981 is 13,392,148,000 hectares (Table 4). Out of this 2.36 per cent area is covered by inland bodies of water, i.e. lakes, rivers, etc. Out of the remaining land area the percentages of cropland, grassland, forest land and other land are 10.84, 23.27, 30.56 and 32.95, respectively. Other land includes areas occupied by roads, rail lines, constructions, human habitations, barren wastelands and deserts.

There is great variation in the distribution of these land biological systems in different regions of the world. South America and the USSR share between themselves almost half of the world's forests. Africa possesses one-quarter of the world's grassland and 17 per cent of the world's forests. Asia with more than half of the world's population to support possesses 31 per cent of the world's croplands, 19 per cent of the world's grassland, and 13 per cent of the world's forests (Table 5). India with 15 per cent of the world's population possesses 11.7 per cent of croplands, 0.4 per cent of grassland, 1.5 per cent of forest land and 1 per cent other land.

Considering the world as a whole, the world's forests have the potentiality of providing for the needs of a population much higher than those of today. At present, about one-third of the world's forests are inaccessible, and only one-third are in use.

(c) Depletion of forests

It is estimated that closed forests are disappearing at the rate of 10 million hectares per year. Trees are falling victim to urbanization, industrialization, desertification and exploitation of forests to meet the requirement of fuel and raw materials for timber, pulp, paper, newsprint, plywood, particle board, paper board, match industry, railway sleepers, sandalwood carving, fragrant oil, etc. During the 1970s the total annual fellings were 1,700 million cubic metres which was slightly more than 50 per cent of the estimated gross increment of the world's forests. But considered region-wide a different story emerges. Sixty per cent of felling practices in the world are without any plan and so destructive. Even in Europe where forests in use were under a working plan fellings exceeded the allowable cut.[1]

In developing countries more than 1,500 million people depend on wood for cooking and keeping warm and consume annually 1,000 million m^3 wood, which constitutes 80 per cent of their total wood use.[2] The effect of such massive demand is denudation of the land of trees over vast areas.

Overgrazing, deforestation, logging, indiscriminate felling are resulting in the alarming destruction of India's forests. Water tables are falling, more and more rivers are drying up, and floods are eroding the topsoil devastatingly. It is estimated that, at the present rate of clearance, the remaining area of unlogged productive tropical forests in the world will be halved by the turn of this century.

(d) Depletion of grassland

The grasslands that provide food to the world's 3,000 million domesticated grazing animals are falling victim to their overgrazing as well as conversion into croplands. There is ample evidence of over-grazing of pastures in Africa with the resultant soil erosion. Cattle, goats and sheep do not behave like wild ungulates which maintain their grassland habitats well. But domesticated animals, which encroached into the latter's territory under human protection, never spread out over the grasslands. They keep themselves closely together, graze, drink, lick salt, walk, ruminate together and completely uproot the vegetation of the grazing area before they move to other sites. This is one of the reasons why the Rajasthan desert is growing and the grazing tracts of forests, throughout India, are losing the regenerating capacity to recover. Grassland degradation in India has become nearly total.

(e) Depletion of croplands

Croplands provide food for man. Croplands have been established by man by replacing forests and grasslands. They are falling victim to urbanization, transportation, industrialization, soil erosion, water-logging and salinization. (Refer to Sub-unit 5.1.4.)

(f) Threatened plant species

The International Union of Conservation of Nature and Natural Resources (I.U.C.N.) Threatened Plant Committee has estimated that at least 25,000 species including lower plants such as mosses, liverworts, fungi, lichens and seaweeds are endangered due to habitat deterioration, clearance, uprooting and construction.

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[1] Watter H. Pawley. Possibilities of increasing world food production. Rome, FAO, 1967 (pp. 207-209).

[2] IUCN. Living on borrowed time. The Unesco Courier, Paris, Unesco, 33rd year, May 1980 (p. 88).

Possible ways

(a) Restoration of vegetation cover

Restoration of the vegetation cover in grasslands, forests, deserts, as well as other areas is essential to redress much of the disturbed ecological balance of the globe.

(b) Restoration of forest cover

Forests play two vital roles for man: protective and productive. They stabilize soil, conserve water, protect the environment and contribute to the survival of man. They also produce and provide material comfort. Time is now ripe to balance these two roles and manage the forest resources. Restoration of the forest cover is vital for protecting the cropland from erosion and flooding as well as for the regulation of the water supply on which the growth of food crops depends. The productive potential of forest areas should be assessed and measures taken to reach the target. By harnessing natural resources of climate and soil with the selection of valuable and fast-growing tree species for the purpose of planting, tending and harvesting as well as by allowing selective grazing, the productive potential can be reached. Steps should be taken to make people forest-conscious and enlist their willing co-operation to protect forests.

(c) Social and agroforestry

Social forestry should be promoted at the community level to convert barren lands into woodlands and to introduce agroforestry to manage land as well as incorporate appropriate botanical remedies for the specific nutritional maladies of the community. Farm forestry in developing countries is indispensable. Forests developed on the farm and village commonland can meet the domestic and agricultural requirements.

(d) Recovery of waste and denuded land

Where trees and crops cannot grow, some grasses can. Grasses improve the soil structure and prevent soil erosion and provide natural and nutritious feed for cattle. Waste and denuded land can be managed to grow grass and solve fodder problems.

(e) Management of grassland

The grasslands provide natural pastures for cattle, sheep and goats but, under consistent overgrazing, they can be turned into desert. Proper attention should be given to pasture management. By controlled grazing and reseeding with superior species, natural grasslands can be regenerated with useful grasses.

(f) Reclamation of desert

The deserts can be reclaimed. It has been estimated that 50 million m^3 of water is present at great depth under the Sahara desert. This can be brought up through solar energy and utilized. The Rajasthan desert also contains water in deeper layers. Through wind and solar power, water can be surfaced and utilized for cultivation.

(g) Economical land use

Damage to cropland, through human activities and the natural processes of desertification, can be minimized and economic benefits maximized if land use in a given environment is based on ecological considerations.

Check yourself

1. What are the roles of: (a) forests; (b) grasslands; (c) social forestry.

2. Why the vegetation cover is important for our survival.

3. How can we recover:

   (a) our barren lands in the villages?

   (b) arid lands in the Rajasthan desert?

4. Make a survey of your local environment and find out the plant resources and their problems. Suggest some remedial measures which are practicable.

5.1.7 Our animal resources

The problems

(a) Animals in natural biosystems

Animals are integral parts of biosystems. In natural biosystems forests and grasslands, wild animals live in harmony with the vegetation, climate, water resources, and the soil, as well as maintaining the balance among one another and preserving the genetic species on a sustained yield basis. The grassland with a natural biosystem is a much more productive unit than that which is utilized by livestock. (Refer to 5.1.6 - Depletion of grassland.) Wildlife in its variety and beauty is a magnificent asset as well as a great heritage of man.

(b) Human interference and extermination of the wildlife

The wildlife has become most vulnerable in the hands of man. The extensive exploitation of forests, poaching and illegal shooting of game in forests, the clearing of forests and grasslands for extending cultivation and the counter-measures for protecting crops from the ravages of wild animals are responsible for taking a heavy toll of wildlife and extermination of several species. Within the last three hundred years, many species of birds and mammals have disappeared and many are on the verge of extermination. In India, two-horned rhinoceros and cheetah have become extict only during the first quarter of this century. IUCN's Red Data Book lists more than a thousand vertebrate species and sub-species threatened with extinction: 305 mammals, 400 birds, 138 amphibians and reptiles and 195 types of fish. These include Indian wild ass, Manipur brow-antlered deer, mountain tapir, Siberian tiger, blue whale, giant otter, Haitian solenodon, aye-axe, Hawaiian duck, Japanese crested ibis, Attwater's prairie chicken, monkey-eating eagle, hawskbill turtle, China alligator, Santa Cruz long-toed salamander, Illinoi's chorus frog.

(c) Domesticated animals and their use

Man has domesticated animals for various purposes - for getting meat, milk, eggs, labour, wool, fur, skins, for hunting and keeping pets. At present, about 18 per cent of the total world food is contributed by meat, milk and eggs. Gross products in 1981, as per FAO, included more than 142 million metric tons of meat, 233 million metric tons of milk and 22 million metric tons of eggs. In 1982 more than 230 million cattle, 9 million buffaloes, 795 million pigs, 396 million sheep and 171 million goats were slaughtered for the purpose of meat supply. Horses supplied 569,000 metric tons of meat and poultry 28,696,000 metric tons.

(d) Consequences of meat production

Growing livestock at the expense of foodgrains for meat production is highly uneconomical. It enhances environmental cost. 'Thus while about 280 kcal of energy are needed in countries like India and Indonesia to produce 1 kg of rice protein, as much as 2,860 kcal are needed to produce 1 kg of wheat protein and over 65,000 kcal to produce 1 kg of beef protein in the United States.'[1] Ninety per cent of energy input in the U.S.A. are derived from non-renewable resources.[1] Grains and protein foods are imported into Europe to produce beef.[2] The example of the Sahel area of North Africa is precarious: 'Owing to the demand for meat in neighbouring countries the Sahel people increased their herds, which, after the grazing was exhausted, sought their food from other plants and trees over a wide area. This reduced the rainfall and gradually led to the drought which killed the animals, and might have killed the people too if massive quantities of food had not been sent in from all over the world'.[3] Further, there are several disadvantages which are inseparable from flesh food: change of intestinal flora from fermentative to putrefactive bacteria leading to absorption of poisons inimical to health; inhibition of natural synthesis of Vitamin B_{12}; perversion of metabolism due to animal toxins; fear poison released at the time of slaughter; more chances of coronary disease of the heart due to animal fat cholesterol; more chances of getting parasites and worms peculiar to the livestock.

Besides the animals, it is presumed that the number of birds slaughtered by netting or shooting may be as much as three times that of the animals. If we calculate that one bird would devour at least 100 grammes of noxious insects, including mosquitoes, in its single migratory flight 1,000 million birds would devour 100 million kilogrammes of these harmful insects. In the absence of the birds we have to take recourse to spraying, on the fields, gardens and orchards, insecticides and pesticides which find their way into the human body.

Possible ways

(a) Maintenance of existing biosystems and bioreserves

For the survival of man, the survival of biosystems is essential. The following measures are essential to preserve our wildlife resources. The existing natural ecosystems with their wildlife throughout the world should be maintained as representative of the worldwide network of reserves.

The existing forest game reserves - national parks and sanctuaries - should be protected by establishing a buffer zone around each. The local communities should be helped to realize that the preservation of forests contribute to the continuation of the wildlife, preservation of genetic species, maintenance of climate, conservation of soil, and regulation of moisture, stream flow and water supply, which are vital ecological necessities for the protection and improvement of the environment.

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1. C. Gopalan. Nutritional problems in developing countries. World nutrition and nutrition education. Paris, Unesco, Oxford, 1980 (p. 37).
2. The English Ecology Groups. In harmony with nature, Madras, The Theosophical Publishing House, 1976 (pp. 28-29).
3. The English Ecology Groups. In harmony with nature, Madras, The Theosophical Publishing House, 1976 (pp. 28-29).

Maintenance of the environment brings about all-round improvement. Management of both the wildlife and domestic animals requires judicious adjustment of animal populations to the carrying capacity of the environment. Mechanized agriculture and intensive stock farming have developed mainly in areas with rich soil and favourable climates. Other unprofitable areas are abandoned by human populations. A great opportunity exists before ecologists to develop these areas for the harassed wildlife in future.[1]

(b) Integration of natural and social environments

Man has an inner urge to enjoy beauty and live in harmony with nature. For his own well-being as well as of nature, the natural and social environments can be integrated for a wholesome development.

(c) Cow's stabilizing role in Indian economy

Marvin Harris, the author of 'Cows, pigs and wars and witches' analyses the importance of the cow in India and its stabilizing role in the Indian economy. The cow is a 'factory' for producing bullocks, fuel and fertilizer. Compared to the western cow which competes with man for food, the Indian cow by and large, lives on grass, stubble and garbage. Even the skinniest barren cow goes on supplying fuel and fertilizer. The cattle in India basically convert items of little direct human use into products of immediate utility. The dead cow supplies leather as well as bones. **If the cow is scientifically** bred and effort is made to provide enough rations the cow will play a bigger economic role. As natural grasslands in India are limited (See Table 5) 165 million hectares of cultivated land supports not only 700 million people but also 357 million cattle. Crop residue, serving as the major bulk of feed are very poor in nutritive value. New cropping systems are being evolved to harmoniously blend crop and livestock farming programme and introduce rich nutritious fodder crops in relay cropping. High protein fodder crops include bersean, lucerne, cowpea, and other leguminous plants; the non-leguminous crops include maize, jowar, bajra, oats and fodder grasses like elephant grass, giant napier grass, guinea, para, rhodes and dinanath.

Check yourself

1. What benefits does man get from domestic animals?
2. Mention four points to show how the Indian cow is an economic asset.
3. Justify the statement: 'For his own survival man should preserve wildlife?
4. What steps would you suggest so that man can live in harmony with wildlife?

5.2 Socio-cultural factors behind environmental problems

The deterioration of the environment and its resources is caused by several factors, the main factors being population explosion, the side effects of the application of science and technology, and the differing socio-economic systems. The menacing demographic growth is leading to increasing incompatibility between resources and the number of human beings. Science and technology have made possible tremendous progress by mankind but, side by side, have added new problems. Agrochemical pollution, waterlogging and deprivation of genetic resources are the consequences of the application of agricultural technology. The drug menace infecting the developing world is caused by the misuse of medical technology by the world's drug industry. Pollution of air, water and land, environments and ugliness and depredation of resources are the consequences of the use of energy technology and industrialization.

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[1] François Boweliere. A new balance between man and nature, The World in 1984, Vol. I, England, Penguin Books Ltd., 1965 (p. 54).

The differing socio-economic systems with differing value systems are causing growing inequalities in human societies and furthering environmental deterioration. Affluence is making greater demands on the environment for ever-growing per capita energy and material consumption and causing wastefulness and increase in pollution. Underdevelopment in vulnerable sections of human population in the developing world is causing environmental deterioration due to poor environmental sanitation, the uprooting of forest and woodland to meet the demand for firewood and the loss of productivity through disease and malnutrition.

5.2.1 Population explosion

The main cause of environmental problems is the rapid population growth increasing alarmingly the incompatibility between the environmental resources and the number of human beings.

Ten thousand years ago when man was a hunter, a fisherman and a food-gatherer, his number was strictly limited by the number and availability of his prey. As about 5 km^2 of hunting ground was necessary to support one predator, 50 million km^2 of such land, available on the globe, would have supported a total world population of 10 million.[1] The development of agriculture, domestication and advances in technology provided enough to support a larger population which had reached 500 million by 1650; and after 200 years, by 1850 1,000 million; but the population doubled after 80 years in 1930 to reach the figure 2,000 million, and took only 46 years to become 4,000 million in 1976. (Refer to Figs. 15, 16 and Table 6). Thus not only the number of people is increasing but the doubling time is also decreasing. Consequently, increasing demands are being made for food, water, shelter, fuel, energy and minerals, resulting in the decrease of per capita arable land and forest land; the increase of population density; the shortage of food, water and fuel; the increase of pollution; the rise of socio-economic conflicts and the widening of disparity between socio-economic systems. The gross effect of all this is the deterioration and depredation of environmental resources.

Check yourself

1. Cite examples of how the doubling time of population growth is decreasing.

2. The deterioration and depredation of environmental resources are caused by the population explosion. Explain.

5.2.2 Consequences of application of science and technology

Advances in science and technology and their application have ushered in overwhelming development and betterment in the world in the form of (a) the green revolution through modernization of agriculture (improved seeds, fertilizers,

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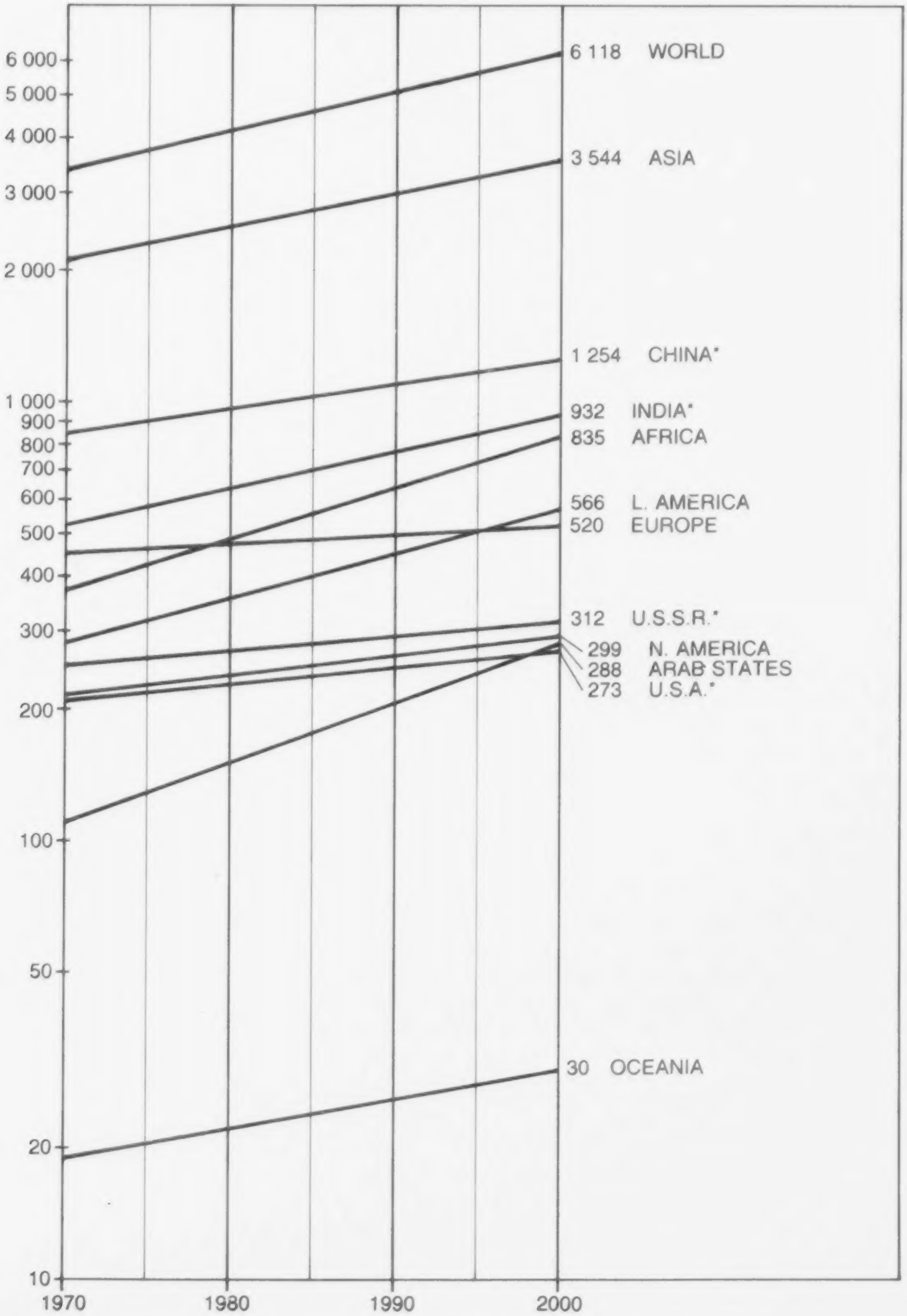
[1] Marston Bates. Man in nature, New Delhi, Prentice-Hall of India (Private) Ltd., 1963 (pp. 54-55).

POPULATION 1970-2000
(MILLION)

Figure 15: Growth in the population (all ages) of the world and major areas, 1970-2000



Source: Adapted from figures in Unesco Statistical Yearbook 1980, 1982.

Table 6: Estimated population 1970-2000

	Age-Group	million 1970	1980	1990	2000	Percentage of population 1970	1980	1990	2000
World	All	3,695	4,431	5,241	6,117	100	100	100	100
	0-4	509	542	610	657	13.8	12.2	11.6	10.7
	0-14	1,382	1,549	1,693	1,874	37.4	34.9	32.3	30.6
Developed countries	All	1,072	1,164	1,249	1,328	100	100	100	100
	0-4	91	91	96	96	8.5	7.8	7.7	7.2
	0-14	286	273	281	288	26.7	23.5	22.5	21.7
Developing countries	All	2,623	3,267	3,992	4,789	100	100	100	100
	0-4	418	451	514	561	19.9	13.8	12.9	11.7
	0-14	1,096	1,276	1,412	1,586	41.8	39.0	35.4	33.1

Source: (1) Unesco Statistical Yearbook 1982

(2) Percentage calculated from the above data

pesticides, irrigation, improved breeds, etc.); (b) the health revolution through the discovery of infection killers; the invention of miracle drugs, antibiotics, sulfa drugs; the prevention or control or treatment of many diseases; the improvement of environmental sanitation; and (c) industrialization through profitable exploitation of fossil fuels. But it has also brought in new environmental problems.

(a) Effect of modern agriculture

Modern agriculture pivots upon high-yielding seeds, fertilizers, pesticides and irrigation. The agricultural operations in the affluent countries are highly mechanized, capital-intensive, labour-saving and are based on high consumption of energy derived from non-renewable sources of the earth. In the developing countries the agriculture is labour-intensive. High-yielding varieties demand the use of more fertilizers which in turn require more water. Wide use of high-yield needs, fertilizers which in turn require more water. Wide use of high-yield needs, fertilizers, pesticides and provision of water through canal irrigation have given rise to several environmental problems.

Waterlogging

Irrigation from major works requires construction of costly dams and canals. Canal irrigation leads directly or indirectly to the rise of the water table, culminating in waterlogging and the related problems. Examples may be found in India and other parts of the world.

Agrochemical pollution

Runoff water becomes loaded with fertilizers and pesticides and pollutes the soils, canals, rivers and seas. Polluted water inhibits fish growth. Health of man and animals is adversely affected by pesticide residues. The latter have led to the extinction of certain species, the development of resistance in pests and the outbreak of new pests.

Many agrochemicals have been banned or severely restricted in a number of countries and identified by the World Health Organization as excessively toxic or hazardous. But these are freely used in many developing countries.

Among the pesticides banned, withdrawn or severely restricted in various countries but used freely in India are shown in Table 7).

Table 7: Current use of some hazardous pesticides in India

Pesticide	Effect	Current consumption ton/annum	area in ha.
DDT	Carcinogen	3,500 (agri.) 4,000 (p. health)	2.5 million
BHC	Highly hazardous carcinogen	33,000	11.5 million
Methyl parathion	Extremely hazardous	3,000	12 million
Heptachlor	Three times as toxic as DDT	150	300,000
Lindane	Moderately hazardous	60	

Source: PRAFUL BIDWAI, Hazards of Pesticides, The Times of India, New Delhi, 15, 16, 17 December 1982.

Besides the above many other undesirable pesticides are still in use in India, the consequences of which are not yet realized.

Deprivation of genetic resources

The advent of scientific plant-breeding produced modern high-yielding varieties, absorbing only a very small proportion of the ancient stores of genetic variation. The same, or closely related, varieties are grown in many parts of the world ushering in dramatic improvement in food production; but, side by side these limited varieties are replacing the traditional wide range of varieties throughout the world depriving the latter of valuable genetic resources.

(b) Misuse of medical technology: the drug menace

The American Food and Drug Administration found out in the early 1970s that 60 per cent of the 2,000 pharmaceutical products on the U.S. market, which were investigated had no therapeutic value and some were ordered off the market. The World Health Organization also claims that virtually 90 per cent of the health needs of developing countries can be met with just 1 or 2 per cent of the drugs available there. In India, for example, it has been estimated by a government committee that the basic health needs of the country can be met by 116 generic drugs, which is less than 1 per cent of the 15,000 brand drugs sold on the market.[1]

The World Drug Industry operated by multinational drug companies is playing havoc with the life of the people, especially of the Third World. These companies, based in western countries, are taking advantage of less rigid government restriction on the sale of drugs in the Third World to make massive profits. Not only that, they also apply double standards in the sale of drugs in developed and developing countries. For example, Bournvita is sold in Britain as 'The goodnight drink' and in Malaysia as a drug offering energy and vitality. Depro-Provera, the hormonal contraceptive, which is deemed to be dangerous, has never been used in the U.S.A. whereas it is being used by women in over 82 developing countries as a means of curbing population growth under a promotion campaign of the International Planned Parenthood Federation.[1] In a laboratory test this drug has caused a high incidence of cancer in animals.

The drugs which have failed to pass the stringent controls in the western countries are tested in the Third World countries by using the people as 'guinea pigs'.[2]

(c) The energy pollution

Industrial energy supports the modern civilization. To meet the huge demand for energy, fossil fuels are explored for, processed, transported and consumed; each of these steps is beset with environmental hazards: fire, pollution, disruption, ugliness. Exploration for fossil fuels causes considerable land or ocean disturbances. The ecosystem is disrupted by excavation for coal, drilling in the ocean floor and ground and pumping petroleum and natural gas. Oil spills pollute vast stretches of land and ocean surface. Oil slicks from damaged oil pipes, tankers or wells may spread over vast distances. Leakage during transportation

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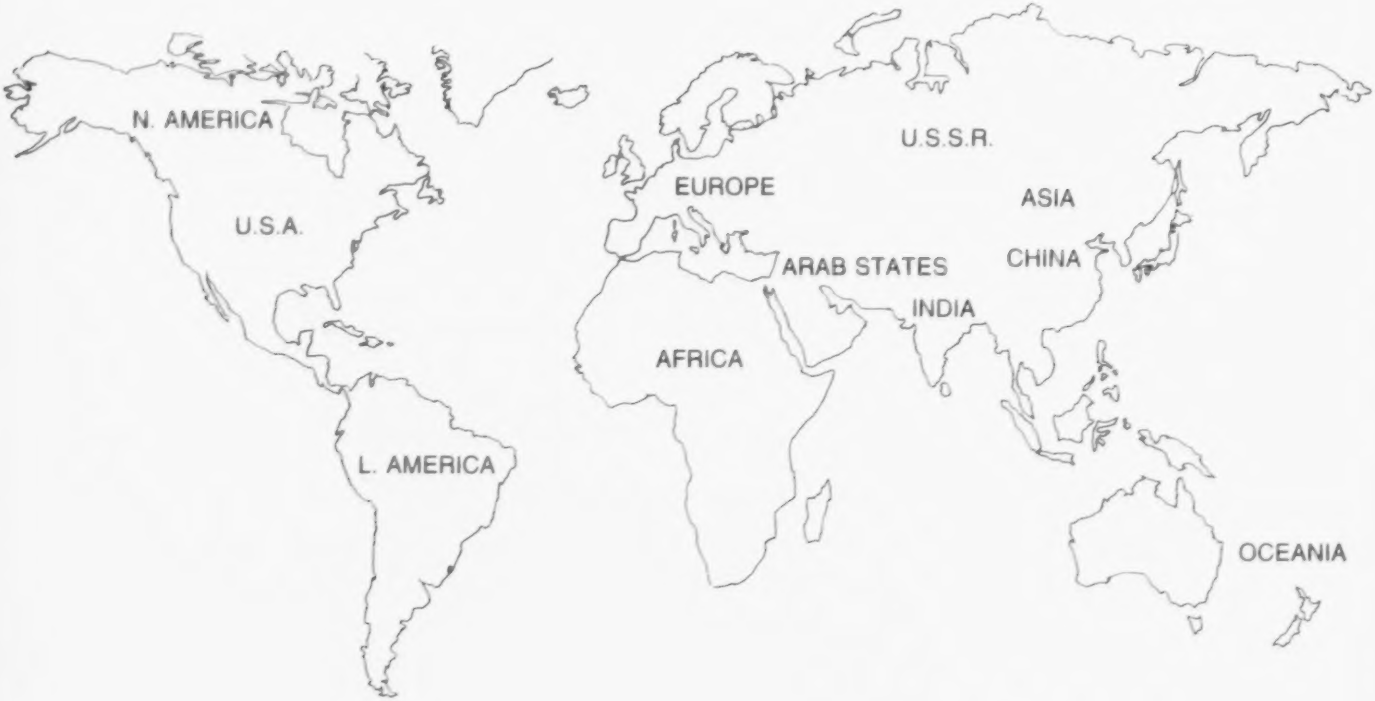
[1] Ken Laidlaw. No business with health: Campaign against world drug industry, Development and Co-operation (D&C), Bonn, German Foundation for International Development 6/1981, (November/December), p. 23.

[2] M.S. Kamath. The Third World: Guinea pigs for multinationals, Sunday Standard Magazine, New Delhi, Indian Express Newspapers, Pub. Ltd., 17 May 1982, p. 2.

Figure 16: POPULATION DENSITY 1980


N. AMERICA
U.S.S.R.
EUROPE
ASIA
U.S.A.
ARAB STATES
CHINA
INDIA
AFRICA
L. AMERICA
OCEANIA

WORLD	33	EUROPE	99	U.S.A.	24
N. AMERICA	12	OCEANIA	3	CHINA	100
L. AMERICA	18	AFRICA	15	INDIA	202
ASIA	93	U.S.S.R.	12	ARAB STATES	13

also causes land and water pollution. Pollution of the oceans threatens and disrupts marine life, some important for fishing industries. Half of the sea life today is dead and the other half is dying fast.

Nuclear fission plants, which generate nuclear energy, can cause radioactive contamination of the environment. The natural environment may not recover from this hazard even in thousands of years.

(d) The effects of industrialization

The application of scientific and technological innovations leads to industrialization. Industrialization increases not only total and per capita productivity but also consumption of energy and natural resources. It promotes intensive urbanization. It increases the rate of flow of capital and materials throughout the economy and influences population distribution patterns, socio-economic status and value systems. (Refer to 5.2.3.)

Industrialization and urbanization leads inevitably to encroachment on and deterioration of environment and irreversible changes in the landscape, on a large scale, for the exploration and exploitation of mines and quarries, the construction of plants, buildings, houses, rails, roads, highways, reservoirs and dams. Immense environmental degradation is caused by the growing amount of wastes and toxic substances from industries, especially highly pollutive industries like alcohol distillation plants, pulp and paper mills, mining firms, petroleum refineries, tanneries; from the sewage of cities; fertilizers and pesticides used in fields; from carcinogenic and toxic gases from transportation systems; and from huge piles of solid waste from consumption. Emission and disposal of these pollutants to the environment have resulted in an increasing intensity of air, water and land pollution on an extensive scale and exposed humanity to unexpected misery. (Refer to 5.1.2 and 5.1.3.)

Check yourself

1. Discuss the following statement:

   'The application of science and technology has ushered in overall development and betterment in the world, but it has also brought in new environmental problems'.

2. Explain how modern agriculture is bringing about environmental deterioration.

3. What steps do you suggest to overcome the drug menace in the Third World?

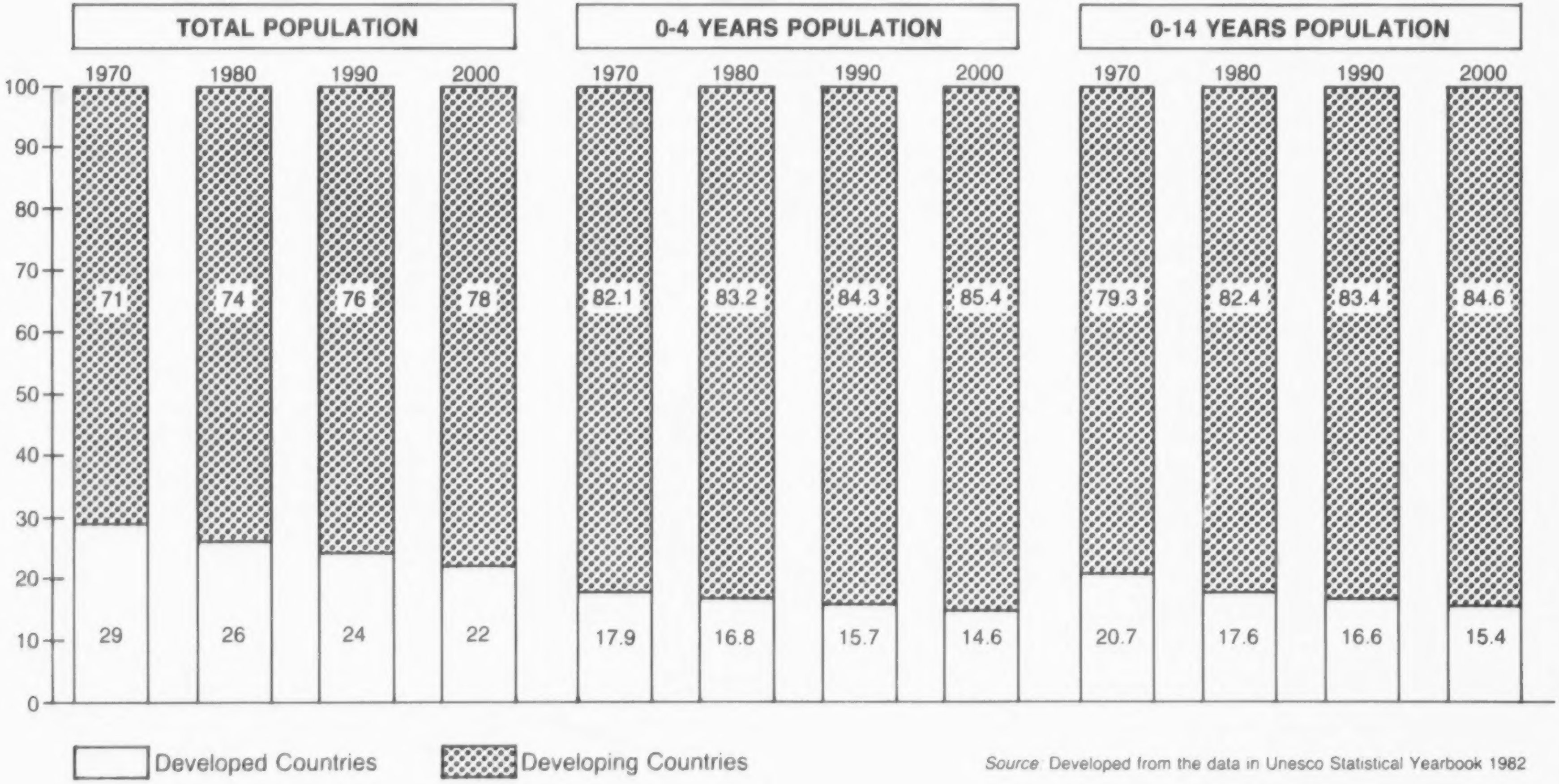
4. State specifically how exploration, production, transportation and consumption of industrial energy are beset with environmental hazards.

5. Specify how industrialization has brought about deterioration of environment and irreversible changes in the landscape.

5.2.3 Differing socio-economic systems

Industrialization during the last 100 years has led to a process of economic polarization of the world into the affluent 'haves' and poor 'have-nots'. At present, the ratio of population distribution between the affluent industrialized and the poor developing countries is 1:3 (Fig. 17). Circumstantially, the environmental problems appear to emerge differently in both the systems.

Figure 17: PERCENTAGE DISTRIBUTION OF POPULATION IN DEVELOPED AND DEVELOPING COUNTRIES (World Population = 100)



Source: Developed from the data in Unesco Statistical Yearbook 1982

(a) The 'affluence trap'

Industrialization has made great strides in gaining tremendous economic advancement, achieving modernization of life, and carrying people to a life of affluence. It has given rise to a value system in which a higher and still higher rise in total and per capita energy and material consumption and even wastefulness are considered to be the marks of progress. This value system is supported by the modern industrial economy which is a technical complex in which man may seem to have become a helpless tool. To use the phrase of Francesco di Castri (1980), man is 'carried along by the frantic pace of modern life with scarcely the chance to fully master his role'.

Man has been caught in the 'affluence trap'! The affluent societies 'face complex environmental problems arising largely from the consequences of the past application of science and technology without full regard to the environmental consequences'. They have to contend with 'industrial pollution, high rates of resource use and the social and cultural problems of life in larger cities ...' 'Excessively high standards of living impose undue demands upon the environment ...'[1]

The nutritional pattern (production, processing, utilization of food) evolved by the industrialized countries has, as Gopalan (1977) pointed out in the first International Conference on Nutrition Education, increased ecological cost several-fold. The affluent people depend generally on a plant-animal-man food chain. Out of an average annual per capita consumption of about one ton of food grains in the affluent countries only about 70 kg are consumed directly while the rest are used as animal food to get meat, milk and eggs. Daily protein intake is about 100 gm which is far in excess of physiological needs.[2] (Refer to 5.1.7 for consequences of meat production.) Food supply distance from field to mouth, accompanied with the interference with the natural food, has increased due to the intervention of farming, processing, packaging, transporting, marketing, storing and preparing with a resultant increase in energy expenditure at every stage.

The upper élite minorities of the developing countries are getting intoxicated with the affluent value system of the industrialized countries and pulled into the 'affluence trap'. It is not surprising that the economic polarization is being repeated in the developing countries shattering the judicious exploitation and husbanding of the national environmental resources for the benefit of the entire population of the poor nations. The countries are facing the environmental problems of both worlds.

(b) The 'poverty trap'

Three-quarters of more than 4,000,000,000 people of the world live in the developing countries. In these countries underdevelopment contributes to unemployment and underemployment problems which lead to people's impoverishment. Undernutrition and infection, poor sanitation, poor housing and clothing, and a low level of literacy are caused by poverty. Undernutrition and infection reduce productivity. Loss of productivity leads to poverty and its consequences. It is a vicious cycle. Thus poverty is a trap in which 3,000 million people of the world have been trapped.

Irrespective of developmental efforts, the overall economic development and increase in GNP in the developing countries have not been accompanied by eradication

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1. UNEP document, UNEP/Enved 8, Item No. 39, paragraphs 38 and 39.
2. C. Gopalan. Nutritional problems in developing countries, World Nutrition and Nutrition Education, Unesco - Oxford, 1980, p. 37.

of poverty for lack of social and distributive justice on the one hand, and due to rise of population, on the other.

Major environmental problems arising out of this vicious circle of underdevelopment and poverty are malnutrition and disease, insanitary environment, and scarcity of fuel.

Malnutrition

Many people in the developing regions of the world live below the 'poverty line'. Even if these people spend 90 per cent of their total income on food they will not be able to afford the least-cost balanced diet. 'Poverty line' has engulfed more than 30 per cent of the population in some developing countries and more than 40 per cent in India. According to a recent World Food Survey, more than 400,000,000 people in the developing world receive less than the critical minimum of their food needs.[1]

With the quantity and quality of food being inadequate, undernutrition and malnutrition are inevitable. The calorie intake of an undernourished person is much less than the minimum required to maintain normal body weight and normal activity. A malnourished person suffers from lack of specific nutrients in the diet. Undernourished persons are malnourished also, but the reverse is not necessarily true.

The body's resistance is reduced due to undernourishment and malnourishment and it makes the infectious diseases such as gastroenteritis, colitis, TB, influenza and pneumonia worse. High incidence of infant and child mortality in the developing countries may be directly due to disease but indirectly due to malnutrition (Figs. 18 and 19).

Children below 15 (0-14 years) constitute 39 per cent of the total population in the developing world. At present, there are more than 1,300,000,000 children. Between now and the year 2000, about 3,500,000,000 more will be born.[2] But this is the population sector which is and which will be subjected to malnutrition, disease and death more severely than others.

The Executive Director of the World Food Council has stated that 'up to one-third of all children born alive die from malnutrition and disease before they reach the age of five. Of those who survive, between one-quarter and one-half suffer from severe or moderate protein-energy malnutrition in the poorest countries'.[3]

Chronic malnutrition in the early years of life stunts the growth of children, hinders the process of brain development to its optimum, affects their intelligence and makes them unable to achieve their full intellectual potential forever. Thus, the malnourished children who grow into adulthood, have poor stamina and poor mental attitudes and psychomotor competencies.

The nutritional problem in the developing countries has already become formidable even at present and, in the coming two decades, the magnitude will increase. Gopalan (1978) has warned: 'The prospects of our being able to control some of the major infectious diseases in the developing countries in the coming decades would appear to be reasonably bright. On the other hand, futuristic projections of trends in population growth and food production present a rather grim picture. Malnutrition

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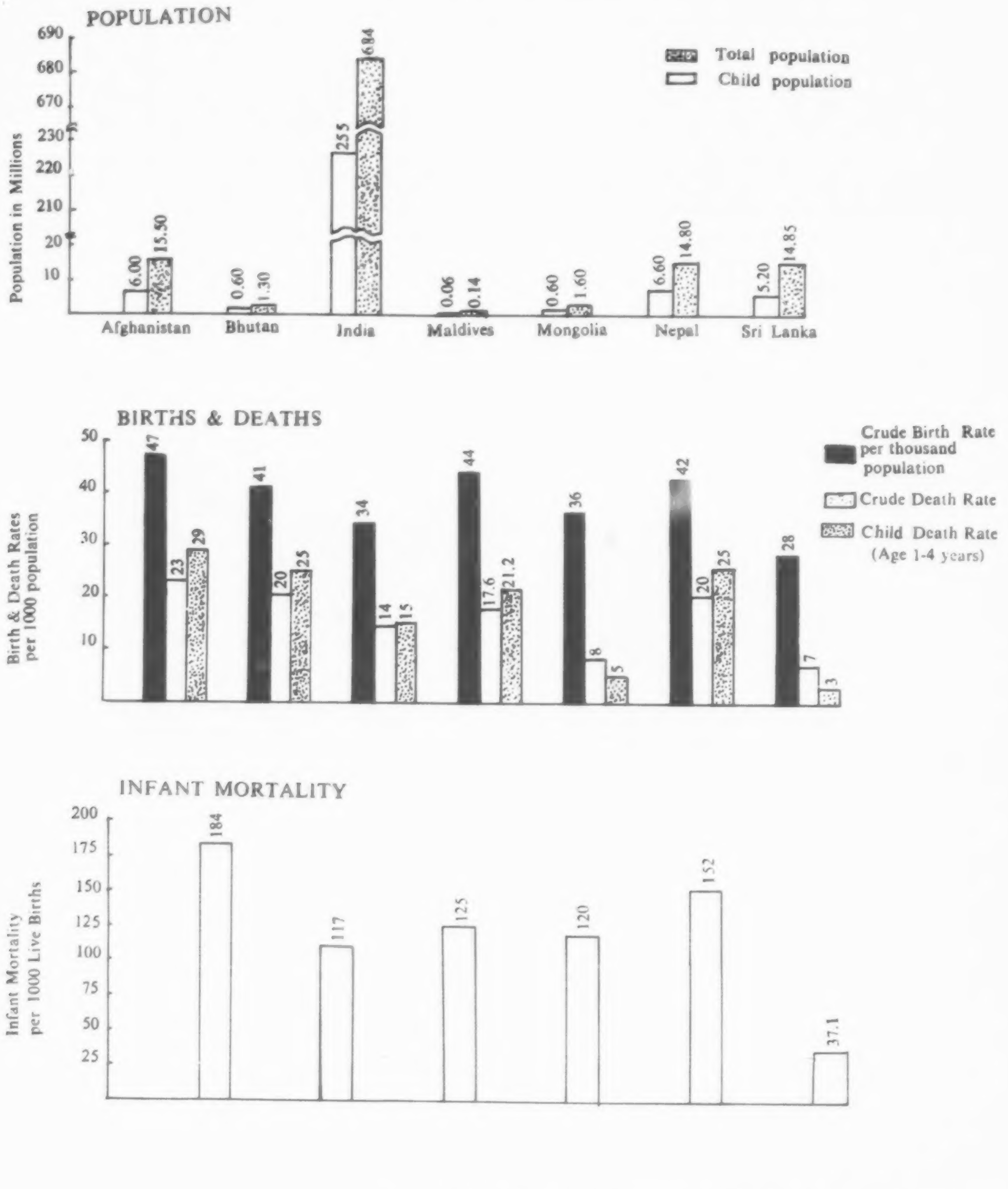
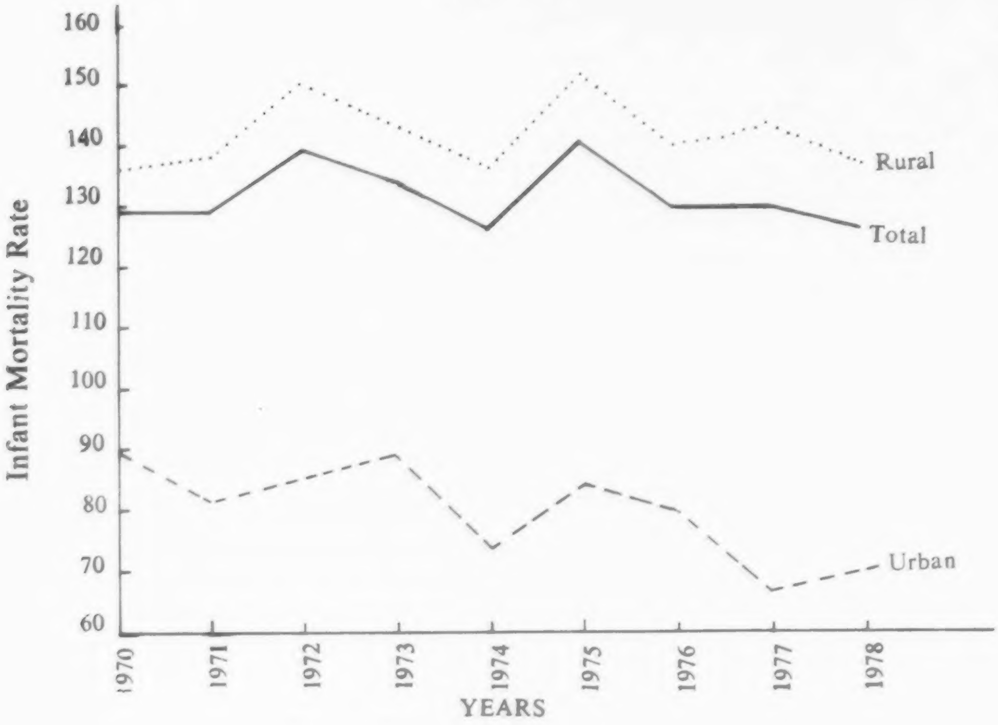
1. UNICEF, Children, UNICEF and Education, Code 384 (p. 14).
2. Ibid., p. 23.
3. Ibid., p. 14.

Figure 18: A REGIONAL PROFILE

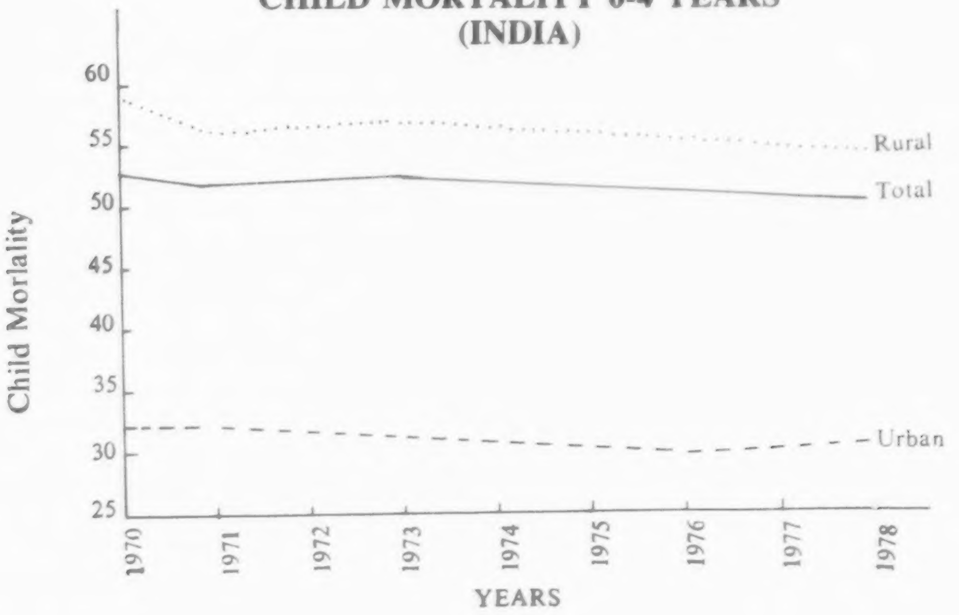


From: UNICEF, future 1981 fourth quarter, UNICEF Regional Office for South Central Asia, New Delhi

Figure 19: INFANT MORTALITY RATE 1970-78
(INDIA)



CHILD MORTALITY 0-4 YEARS
(INDIA)



From: UNICEF (1981), Child Atlas of India, UNICEF Regional Office for South Central Asia, New Delhi will thus emerge as the major health problem of the developing world in the next few decades'.[1]

Poor environmental sanitation

There is high incidence of infections in the developing countries due to the lingering existence of two fundamental problems of environmental sanitation: unsafe water supply and unhygienic disposal of waste, especially human excreta. In communities with high incidence of 'digestive diseases', there is no faecal-oral barrier, i.e. there is a continuous circulation of the faecal matter from anus to mouth through polluted water, finger nails, food and flies.

Polluted water causes several infectious diseases such as diarrhoea, dysentery, typhoid, paratyphoid, cholera, giardiasis, jaundice (infective hepatitis), polio, worms and gastroenteritis. It is also responsible for spreading malaria, trachoma and conjunctivitis. It has been found that one out of every four sick persons is sick because of polluted water.

Unhygienic disposal of waste favours the spread of diseases. Exposed wastes breed flies which carry the gastro-intestinal germs. Effluent water from homes running into open village streets and open drains favour breeding of malarial mosquitoes. Open field defecation transmits hookworm infection to bare-footed villagers. Modern scientific knowledge claims that if rural sanitation is properly managed then 80 per cent of infections will be eliminated. But the sanitation problems linger on.

Scarcity of fuel

The wood fuel crisis in developing countries is even at present formidable. (Refer to 5.1.1 and 5.1.6.)

Destruction of forest and degradation of the soil are major environmental problems arising from fuel crises.

Check yourself

1. Explain with specific examples how the nutritional pattern evolved in the industrialized countries has increased ecological cost several-fold.

2. Write, in brief, on the following:

   (a) 'affluence trap'

   (b) 'poverty trap'

   (c) poverty-line

   (d) faecal-oral barrier

3. Discuss the statement 'Malnutrition will emerge as the major health problem of the developing world in the next few decades'

4. Name: (a) two fundamental problems of environmental sanitation, (b) five infectious diseases caused by polluted water.

5. Explain how the burning of cowdung is depriving the soil of valuable nutrients.

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[1] C. Gopalan. Nutritional problems in developing countries, World Nutrition and Nutrition Education, Paris, Unesco - Oxford, 1980 (p. 38).

5.3 Strategy for environmental action

Living in harmony with nature

All the varied forms of life on our globe are the expressions of the evolutionary process of nature which is whole and all-embracing. Man, an integral part of this evolutionary movement, has become nature's instrument of progress and further evolution of the earth's system. His shaping hand has created the cultural diversity - the variety of the world's humanized landscapes out of the natural diversity. But gripped by the whirlwind of demographic expansion, carried along by the frantic pace of modernization, propelled by his divisive action, motivated by conflicting interests of self, family, community, nation, race or creed, he has also become the agent of exploitation, waste and deterioration of mineral, plant and animal resources and is jeopardizing the harmonious maintenance of the natural balance.

The environmental action calls for a strategy to reconcile the necessity of meeting the basic human needs of food, health, safe water, fuel and shelter, as well as socio-cultural needs. There is also the need to maintain in the biosphere the essential ecological processes and life support systems, the genetic diversity and the sustainable utilization of species and ecosystems. Environmental ethics call for removing discord in the ranks of man, fostering mutual understanding, adapting the laws of economics of nature in daily life, and ushering a life of love and further development in harmony with nature.

5.3.1 Meeting basic human needs

(a) Health for all

High incidence of infant and child morbidity and mortality, prevalence of infectious and dietary-deficiency diseases among vulnerable sections of the population, i.e. children and pregnant and lactating mothers, short life expectancy, low potency of the work force, are all reflections of the precarious status of health in the developing world.

The major causes of low health status are malnutrition and infection. Malnutrition is not only due to poverty and non-availability of food resulting from social and distributive injustice, but also due to ignorance of nutritional facts and undesirable practices. Malnutrition problems can be resolved, to a great extent, if judicious selections of foods are made possible within economic means and available foods are better utilized. Infectious diseases are caused mainly by the lingering existence of two fundamental problems of environmental sanitation, namely unsafe water supply and unhygienic disposal of wastes, especially human excreta. The application of modern scientific knowledge through environmental sanitation can lead to 80 per cent of the diseases being effectively controlled.

Thus, by developing desirable nutrition and environmental sanitation practices in the communities, health problems can be considerably resolved. This can be achieved through environment-based education for all age-groups of the population.

The world has resolved to achieve the Alma Ata goal of 'Health for all by 2000 A.D.'. To achieve this goal action is needed in six priority areas:

(1) universal provision for preventive, promotive and curative services;

(2) availability of these services to vulnerable age-groups - children and pregnant and lactating mothers;

(3) control of the endemic communicable and non-communicable diseases by:

- (i) immunization by the vaccine of BCG, DPT, polio, measles;
- (ii) appropriate treatment for leprosy, TB, goitre, blindness;
- (iii) interruption of transmission of vectors (malaria, filaria, Japanese encephalitis, etc.);
- (iv) reduction of diarrhoeal diseases;

(4) adequate food supply;

(5) safe water supply and sanitary disposal of human excreta;

(6) population education.

The projections and targets for health for all by the year 2000, with a 20-year perspective set by the Government of India, can be seen in the table below (Table 8).

Table 8: Specific targets for health for all by 2000 A.D. for India

	1980	2000
Demographic indicators		
1. Crude death rate per 1,000 population	14.1	9.0
2. Infant mortality rate per 1,000 births	125	below 60
3. Pre-school (0-5) death rate (%)	35-40	10
4. Maternal mortality rate	5-8	below 2
5. Life expectancy at birth (years)	52	64
6. Birth-weight below 2.5 kg (%)	30	10
7. Crude birth rate per 1,000 population	33	21
8. Family size	4.3	2.3
Services		
1. Pregnant women receiving prenatal care (%)	45	100
2. Deliveries by trained birth attendants (%)	20/25	100
3. Population with protected water supply		
Rural (%)	10	100
Urban (%)	80	100

		1980	2000
4. Population with sound excreta disposal			
	Rural (%)	10	50
	Urban (%)	34	100
5. Immunization:			
Pregnant women (TT) (%)		21	100
Infants: DPT (%)		51	100
Polio (%)		18	100

Source: Report of the Government of India to the joint UNICEF/WHO Meeting on 'Strategies for Health by the year 2000 A.D.', 1979.

Data relate to 1978 (Survey on infant and child mortality 1979, Office of the Registrar General (India).

From: An Analysis of the Situation of Children in India, 1981, UNICEF, New Delhi-110 003.

(b) Safe water for all

In developing countries less than 75 per cent of the urban population and less than 20 per cent of the rural population have convenient access to safe water.[1]

Approximately, 10 million people die annually due to water-related diseases. About 5 million infants die every year from intestinal diseases before they complete one year of life. Water-related diseases are the leading killers of infants and children.[2]

The World Health Organization (WHO) states: 'One hospital bed out of four in the world is occupied by a patient who is ill because of polluted water ... provision of a safe and convenient water supply is the single most important activity that could be undertaken to improve the health of people living in rural areas of the developing world'. (Refer to 5.1.3.)

The problem of providing a convenient supply of safe water in a formidable one. In some parts of the world, women and children spend half of their time fetching water. Some have to walk as far as 25 kilometres to reach the source of water. In India the problem villages in the hilly and desert regions where the nearest water sources are 1.6 kilometres away contain toxic elements dangerous to health, or endemic and are carrying cholera and guinea worm infestation. Other villages have inadequate and unprotected drinking water sources. Various schemes undertaken to supply safe water have met with several difficulties. The Evaluation Report on the Accessibility of the Poor to the Rural Water Supply, 1980, of Planning Commission brings out several weak points in the programme. Remedial measures which need to be undertaken

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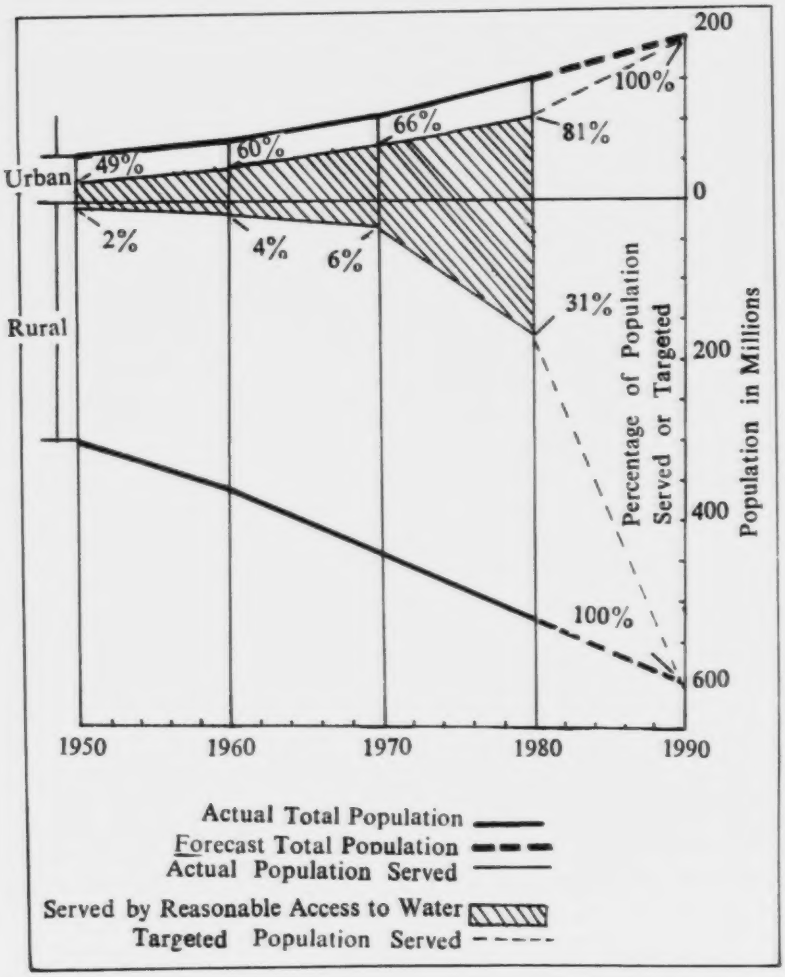
1. UNICEF, Children, Water and UNICEF, Code 381-78-30 (p. 5).
2. Ibid.

Figure 20: ESTIMATED POPULATION COVERED BY SAFE WATER SUPPLY IN INDIA



From: UNICEF (1981), an analysis of the situation of children in India, UNICEF Regional Office for South Central Asia, New Delhi to ensure supply of safe water conveniently through bored/tube/drilled wells and pipes require:

- regular/timely supply;
- adequate number of supply points;
- better management for breakdown and out-of-order conditions;
- provision for separate public points for the poor;
- increase of supply hours.

Side by side, steps should be taken -

- to educate the community to make them aware that water from the open dug wells without parapets and individual collection from ponds, tanks, lakes, etc. is basically unsafe;
- to educate the community to keep traditional sources of water (open well, water-hole , pond, river, lake) safe;
- to convert the open dug wells into sanitary wells by making provision for elimination of contamination.

Water Decade: All the governments in the developing world were signatories to the Mar Del Plata Action Plan adopted by the United Nations Water Conference in Argentina in 1977. UNICEF is assisting governments of more than 80 developing nations to improve and increase water supplies so that everyone gets enough water for drinking, washing, cooking and food production. Committing itself to supplying safe drinking water to all, the Government of India has prepared a decade-long plan with the ambitious target of providing safe drinking water to 190,000 problem villages still not supplied with a source of safe water. (Fig. 20)

(c) Food for all

The global average daily per capita consumption of energy from food is about 2,200 kilocalories (kcal). By meeting this entire energy requirement from the herbivores (second trophic level) it would be equivalent to 22,000 kcal of herbivore which, in turn, would require 220,000 kcal per day of the producer (first trophic level). Assuming that the producer is 1 per cent efficient, the producer would need 22,000,000 kcal per day of solar radiation. With the availability of 500 calories of solar radiation per cm^2 per day,[1] 44,000,000 cm^2 area on 0.44 hectares of land will be required to feed one person. Thus 1.4×10^9 hectares of cropland and 3×10^9 hectares of grassland of the world can feed about 10×10^9 people, which means 2.5 times the present world population, i.e. 4×10^9. Within the coming five decades the population will cross the limit. At present about 3×10^9 metric tons of food is produced annually in the world. Out of this only 2 per cent comes from water in the form of fish. The rest comes from 1.4×10^9 hectares of cropland and 3×10^9 hectares of grassland. Animal food coming mostly from grassland comprises less than 20 per cent of total food production.

Food items coming from different trophic levels enter into the composition of diet of human population in which there is a wide range of variation due to ecological, social, cultural, religious and personal preferences. The greatest advantage lies in taking food items at the producer level. In the long run it may be ecologically necessary to include a higher percentage of vegetable foods in the diet or even to consume a vegetarian diet only.

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[1] Unesco. Teacher's study guide on the biology of human population, Paris, Unesco, 1975 (p. 110).

Agricultural food production can increase through the use of fertilizers, pesticides and irrigation. 'If the developing world were to imitate the current technology of affluent countries for food production, the world's oil wells would run dry in a decade.'[1] Further, it would increase the environmental problems of water pollution from runoff, fertilizers and pesticides, salination and waterlogging. It would also increase the encroachment of cropland for the construction of storage and handling facilities and more roads for quicker transportation.

Scientific development of traditional agriculture for increasing food production has long-range advantages. The traditional farmers in the developing world are organic farmers, i.e. they use organic fertilizers like manure and compost and mechanical methods of weed and pest control. The quantities of organic materials available are also not small.

It has been estimated that the total organic wastes available in developing countries contain about 130,000,000 tons of nitrogen, phosphates and potash nutrients (NPK), which is eight to ten times the amount of chemical fertilizers used.[2] Two vital roles are played by the recycled organic waste: first, it acts as a fertilizer and boosts yield; secondly, it acts as a soil conditioner. The latter role reduces soil erosion, enhances the water-holding capacity of the soil, and helps in the uptake of nutrients added in the form of mineral fertilizers. But very large quantities of organic waste would be required to increase the yield of food enough to meet future needs. A judicious combination of organic and mineral fertilizers would be more profitable. The Chinese supplement organic manures with chemical fertilizers in the ratio of 7 : 3.

To be able to provide adequate food to all in the future, efforts should be made: (a) to grow more food with the use of renewable sources of energy; (b) salinity and waterlogging should be reduced by improving the arrangements for water use and drainage through canals. Irrigation strategies should be changed by resorting to vertical irrigation, i.e., tapping groundwater instead of canal irrigation; (c) the pollution of irrigation water with runoff fertilizers and pesticides should be reduced through the use of judicious combinations of organic and inorganic fertilizers and non-application of harmful and hazardous pesticides. Food wastage should be reduced. The encroachment of cropland should be prevented. The grassland for cattle-raising should be maintained through sustainable utilization. More vegetables should be eaten rather than animal products. New foods from new sources should be developed. Marine ecosystems should be used optimally to catch fish and other foodstuffs from the sea. Lost cropland and grassland should be recovered through proper biological amendment.

(d) Fuel for all

The sub-units on 'Our energy resources' and 'Our plant resources' may be referred to for some detailed discussion of the problem and its consequences. The

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1. C. Gopalan. Nutritional problems in developing countries, World Nutrition and Nutrition Education, Paris, Unesco, Oxford, 1980 (p. 37).
2. Paul Harrison. Food, fuel and zero tillage, Development and co-operation (D&C), Bonn, The German Foundation for International Development 6-1981 (Nov.-Dec.), (p. 13).

twin problems of scarcity of fuel and environmental degradation in developing countries are interlinked. Social and farm forestry as well as utilization of biogas can solve the twin problems. Use of solar cookers on a mass scale in areas where ample sunlight is available during a greater part of the year will substantially compensate for the deficiency. Further, increasing the percentage of uncooked food in the diet will reduce the quantity of fuel need. In Delhi, Dr Moolraj Anand, a retired engineer, initiated, a decade ago, a movement, 'Uncooked food'. It was confined to a few who practised it. It has a lot of potentiality, for the future. The food items included fresh and dry fruits; raw vegetables like carrot and radish; germinated grains (wheat, Bengal gram, green gram, black gram), fresh warm milk (milked from a healthy cow), germinated groundnut; green leaves (coriander, mint, salad, spinach), etc. The keen interest of a dedicated band of workers has been instrumental in popularizing delicious dishes of uncooked foods in a number of camps.

Check yourself

1. What are the major causes of low health status in the developing world?

2. What steps can be taken to achieve the Alma Ata goal of 'Health for all by 2000 A.D.'?

3. What is the extent of the safe water supply problem in the world?

4. Write briefly on what you know about the Water Decade.

5. What is the carrying capacity of the earth so far as the supply of food to mankind is concerned?

6. What strategy should be undertaken to provide adequate food for all in the future?

7. What is the dimension of the fuel problem?

8. How can the fuel problem in the developing world be solved?

5.3.2 Population control

In the ultimate analysis, the root of the solution of environmental problems lies in controlling population growth. With continuing population growth it will be impossible to provide adequate food, clean water, fuel, shelter for the world's new arrivals.

The goal of population control at present is zero population growth. How can it be achieved? It can be achieved in any one of the following ways:

(1) equalizing the birth rate with the death rate;

(2) restricting the fertility rate to 2.5;

(3) making the marriage age high;

(4) obtaining an age structure of the population where the age-groups are all about the same size.

The factors that have been operating in industrialized nations to lower fertility rates gradually to the level of mortality rates are inoperative in developing countries. The economic boom in the former occurred when their populations were still relatively small. The extended family gave way to the nuclear family. The full responsibility for the rearing of children fell upon the separated couple. The marriage age began to rise as couples delayed marriage until they were fully able to shoulder the responsibility of home and children. With the mortality rate decreasing due to the improvement of health services, working couples realized the importance of having fewer children and adopted birth control measures. To meet the felt need of the changing times, governmental family planning services were made available. Thus, it may be seen that the family planning followed rather than preceded the population's recourse to limiting the family size.

In developing countries population growth is taking place due to reduction in mortality rates resulting from the promotion of health services. The advantages of family size limitation have been realized by the educated upper strata of the population, who are taking recourse to birth control measures. This has not filtered to the larger vulnerable sections of the population. Family planning programmes in developing countries are deliberate efforts to reduce fertility and include provision of appropriate forms of birth control, and maternal and child care to reduce infant, child and maternal mortality and illness. Its success depends upon three simultaneous actions: motivation, incentive and adequate infrastructure.

Motivation

The most important factor in controlling fertility is motivation. Efforts to reduce fertility with coercion have often an adverse effect. People can be motivated by educating them through information dissemination about the demographic facts and the social and economic advantages to family and society of family size limitations.

Monetary incentives

Motivation should be accompanied by immediate substantial economic gain for the willing rural population most of whom live hand to mouth. A significant percentage out of two to three million who are being sterilized annually at present in India do so only for money. Because the population has nothing to lose, disincentive has little effect upon them.

Adequate infrastructure

Family planning programmes should include adequate provision of child and maternal health care to be effective. This requires adequate infrastructure to cover the entire population.

Achieving zero population growth: a plan for India

Facts: As per 1981 census the Indian population stood at 685 million. During the last decade, the birth rate has fallen from 41 to 38 and the death rate from 16 to 13 per 1,000 people resulting in an annual growth rate of 2.2 per cent. With a reproductive span of 30 years, the reproductive rate is one birth in every ten years of married life.

A wide range of birth control methods are made available under family planning programmes. Only middle and upper classes take advantage of these and have their own choice of the method. But they form a limited percentage of the total population. For the larger rural and vulnerable section of the population the only practical method of birth control that is widely feasible is sterilization.

The infrastructure available could sterilize seven million during the emergency period. It can handle safely eight million, if willing couples are available.

Ways: With the availability of sufficient incentive, say Rs.1,000 per sterilization, which is roughly the annual income of the individual, it is possible to get sufficient response from the population and sterilize eight million per annum. Within 25 years 200 million married couples would be pulled out of the reproductive pool, lessening population growth by 260 million. By that time the population will reach about 900 million with the attainment of zero population growth. Continuing the drive further will result in a further decline in the birth rate. Total extra expenditure to be incurred for incentive money will be Rs. 1,000 x 200,000,000) Rs.200 x 10^9 in 25 years. J.R.D. Tata, the well-known industrialist and the current chairman of the Family Planning Foundation, has suggested that the government should offer a cash incentive of between Rs.2,000 and Rs.5,000 for each case of vasectomy. He has argued that the addition of another citizen necessitated a capital investment of Rs.7,000 at the minimum, apart from the required recurring expenditure.

Check yourself

1. What are the ways by which zero population growth can be achieved.

2. What efforts should be made in the family planning programmes in developing countries to achieve zero population growth?

3. Suggest a working plan for a family planning programme for the community of your locality.

5.3.3 Environmental education

Education is the only effective short- and long-term instrument to bring about many desired changes in the world. The solution of environmental problems lies in imparting EE to all sectors of population. Out of the five objectives set in the Tbilisi Declaration on Environmental Education (awareness, knowledge, attitude, skill and participation) it is the participation at all levels which is most essential and vital for working towards the resolution of environmental problems.

Environmental action through community contact programmes

The nature of EE is such that its implementation in the formal educational system will make each school an integral part of the community. Environmental action through community contact programmes by schools planned and co-ordinated at the developmental block level may turn out to be the most effective method, especially in developing countries.

The modus operandi of the programme may be:

a conference of the local leaders (village heads, community health volunteers, personnel from the block health centre and block development office, block educational supervisors and schoolteachers of a cluster of 10 to 15 villages) to explore the possibility of participation and co-operation in the Environmental Action Programme;

orientation of teachers of all the schools within the cluster of villages before the programme, and discussion meetings after every two to three months;

contact programme by teachers and pupils involving door-to-door contact with the parents of the pupils and others once a month, common programmes like meetings, exhibitions, plays and recitals;

organization of activities on environmental action (restoring vegetation cover of the locality, environmental sanitation measures, etc.) as per agreed programme through the initiation of pupils and teachers and involvement of the community;

supervision by educational supervisors;

assessment by the block level health, education and development officers.

This methodology which has been found effective in the UNICEF project of nutrition, health education and environmental sanitation at the primary stage (NHEES) in India (Guru 1981) can be utilized to introduce important messages and national objectives into the community and translated into action.

Check yourself

1. What are the objectives of EE set in the Tbilisi Declaration?

2. What methodology can you adopt to educate your community and involve them in planned environmental action programmes?

5.3.4 Community action in ecological restoration

The menace of ecological degradation hits directly the local community which has grown with the environment and it is the direct community action with environmentally sound planning which can bring about ecological restoration. The effectiveness of such action can be seen from the following example.

Chipko Movement and ecological restoration

In the Alakananda belt of the Himalayas, deforestation, illegal tree felling, careless road-building and cultivation on unstable slopes were responsible for frequent landslides and flash floods that wrecked the lives of the people. The Chipko movement[1] was launched by the local people, particularly women, under the leadership of Sri Chandi Prasad Bhatt, the Magsaysay Awardee of 1982, to restrict tree felling on sensitive slopes. After 1977, the U.P. Government was compelled to order a moratorium on logging in a 1,200 km^2 area of the Alakananda catchment. Subsequently, Sri Bhatt undertook watershed management of a vulnerable slide-prone stretch along the pilgrim route to Badrinath along the Alakananda below Joshimath. Villagers were persuaded to surrender their common rights to grazing and make collective efforts to reforest the selected area. The youth of the locality have been mobilized as 'friends of trees'. This sort of local social and community movement is the only effective way for ecological restoration.

5.3.5 Living in harmony with nature

It is the inherent nature of man to live in harmony with his environment. The deterioration and destruction of the environment at local, national, regional and global levels caused by the exploitation of mineral, plant and animal kingdoms of the earth to meet basic and other demands are mostly owing to ignorance of the laws of nature rather than to malevolence.

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[1] In this Movement each participant (man or woman) was to cling (chipko) to a tree to resist felling of the tree at the cost of life. Hence the Movement gained currency as the Chipko Movement.

It is now dawning upon man that his way of life has not only become a menace to the rest of the living world but also to himself. To save himself he has to save the whole world of living, the biosphere. Thus, man is now responsible not only for himself but also for the harmonious maintenance of the natural whole.

The environmental ethics require man:

(a) to overcome his divisive action motivated by self-interests and the interest of family, class, community, nation, race or creed;

(b) to remove discord in the ranks of man, foster mutual understanding, usher a life of love and further development in harmony with nature;

(c) to remove economic polarization of mankind into rich 'haves' and poor 'have nots' and evolve a mechanism of environmentally sound development so that mankind as a whole is benefited;

(d) to realize that environmental problems are the problems of human well-being and that environmental programmes serve the same purpose as development programmes (i.e. protect and improve human well-being) which besides being planned on environmentally sound lines, also protect and improve the environment;

(e) to follow the economy of nature in any circumstances;

(f) to meaningfully contribute to the fulfilment of the aim of the World Conservation Strategy[1] and help achieve its three main objectives of living resources conservation: (i) to maintain essential ecological processes and life-support systems, (ii) to preserve genetic diversity, and (iii) to ensure the sustainable utilization of species and ecosystems;

(g) to strive for meeting global commons - the open oceans, the atmosphere and the Antarctica - safe for the benefit of entire mankind and the biosphere;

(h) to identify oneself with the environment and awaken in the self a loving concern for the environment and commit oneself to making one's environment a place of joy, love, beauty and harmony.

Check yourself

What steps would you take to make your surroundings a place of joy, love, beauty and harmony?

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[1] UNEP. A world conservation strategy, The Unesco Courier, Paris, Unesco, 33rd year, May 1980 (p. 86).

UNIT 6

6. TEACHING METHODOLOGIES

6.0 Introduction

Teaching methodologies to be responsive to the needs of a particular curricular area should take into account the nature of the curricular area itself, the target group of learners, and the available resources for curriculum transaction. Your field experiences must have revealed that the teaching strategies preclude prescription.

There are several strategies available to realize the same instructional objectives. It is the teaching situation and the ingenuity and resourcefulness of the teacher which determine the specific teaching strategy used at a particular point of instructional time. By implication, the proposed teaching methodologies can be suggestive and not prescriptive. At least the teaching methodologies presented in this unit suggest that they have been found useful by practising teachers and/or have research support in realizing the instructional objectives while transacting the EE Curriculum. The Unit purports to provide to you a catalogue of teaching methodologies in the context of EE Curriculum with a proviso that the teachers can use them as they are when it suits the specific instructional situations they encounter. They can experiment, innovate and adopt them to suit their needs.

This unit has been divided into several sub-units. The first sub-unit covers determinants of teaching methodologies in the context of EE Curriculum. The second sub-unit presents elements of instructional design. This is followed by sub-units of specific methodologies like inquiry training/problem solving, clarifying strategies, experimentation and demonstration, and beyond-the-school-wall experiences.

Each sub-unit provides objectives, learning activities and evaluation activities.

For completing this unit it is expected that the teachers already know the goals of EE, its developmental perspective, the essential content of EE, problems and issues involved in EE as well as multidisciplinary approaches to EE. It is also expected that the teachers using this material have the core teaching skills like questioning, reinforcement, explaining, illustrating with examples, stimulus variation, classroom management, conducting and demonstrating experiments, etc. The expectation is not ambitious as this constitutes a part of the pre-service training programme and their teaching experience. If any learner feels that he lacks in these prerequisites, he may go back to concerned curricular area covered in this module and related material concerned with teaching skills.[1, 2]

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1. N.K. Jangira, Ajit Singh, Core teaching skills: Microteaching approach, New Delhi, NCERT, 1982.
2. N.K. Jangira, Technology of classroom questioning, Delhi, National Publishing, 1982.

6.1 Determinants of teaching methodologies

OVERVIEW

Objectives

Upon completion of this sub-unit you are expected to

1. list at least five determinants of teaching methodologies in the context of EE.
2. summarize principles for taking decisions about the methodologies of teaching selected by the teachers in specific teaching situations emerging from the determinants.

Learning activity

Reading the study sheet 'The determinants of teaching methodologies'.

Evaluation

You will be evaluating your performance by answering questions after completing the required reading of the study sheet 'The determinants of teaching methodologies'.

Study sheet 1 - The determinants of teaching methodologies

The selection of teaching methodologies is determined by several factors relating to the curricular area characteristics, specific instructional objectives, learner characteristics, learning principles and instructional resources. The interplay of these factors affect learning outcomes. So, they are considered as determinants of the teaching methodologies. Discussion about these determinants follows.

Curricular area characteristics

Teaching methodologies have to be responsive to the needs of the curriculum area which they purport to cater to. It may be recalled that EE has special characteristics of its own inherent in the approach and emerging objectives. EE has been considered not merely a curricular area but it has been considered as an approach and way of life. Its objectives are not confined merely to knowing and understanding. Its scope extends to action proper threading through the whole life span. Needless to say, the action emerges from a series of appropriate decision-making and problem solving steps. EE related values constitute yet another essential input without which the action is either conspicuously absent or it is incomplete. At the primary stage EE follows an integrated multidisciplinary approach. The specific approach of the EE Curriculum should, therefore, determine the selection matching teaching methodologies.

Instructional objectives

Educational objectives refer to the broad educational goals which different curricular areas purport to achieve. The objectives encompass cognitive, affective and paychomotor domains. The cognitive domain covers knowledge objectives, affective domain covers attitudes and values, and psychomotor domain covers skills and abilities. Instructional objectives are specific performance that the learner acquires through particular instructional procedures used in particular teaching episode or sets of teaching episodes comprising a teaching unit or a lesson. By implication instructional objectives are stated in behavioural terms specifying the parameters of learner performance. The instructional objectives are obviously derived from the educational objectives envisaged for a curricular area. Considering the approach and focus of the EE curriculum, objectives have been visualized at four levels (Unesco, 1980). The four levels of EE objectives are:

1. Ecological foundations level.
2. Conceptual awareness level (issues and values).
3. Investigation and evaluation level.
4. Environmental action (skills level).

The teaching methodologies and the teaching procedures should be matched with the instructional objectives. The effectiveness of instruction will be determined by the fitness of the objective methodology match. For example, if the instructional objective is related to an environment-related issue, a discussion, probing based inquiry, or problem-solving approaches will be suitable. If the instructional objectives are related to an environment related-value, value-clarifying strategies like reaction sheets, clarifying responses, clarifying discussion will be appropriate. For the instructional objective relating to foundational information, information giving strategies like expository, explaining and illustrating approaches will be helpful. So, instructional objectives play a vital role in taking decisions about the selection of appropriate teaching methodologies.

Learner characteristics

Learner characteristics also determine the teaching methodologies to be used. Children at the primary level are exuberant and like action. They are interested in activities, play and exploration. Their attention span and perseverance to carry on the same activity continuously are also limited. It implies that the instructional activities are to be varied. Their urge to inquiry can be harnessed for inducing learning. The socio-cultural milieu from which the children come also affect decisions about the selection of appropriate teaching methodologies. The prerequisites required for the learning of the new task is yet another significant learner characteristic for decision-making for selecting the teaching methodology. For detailed discussion one can refer to Bloom (1975).[1]

Learning psychology

As pointed out earlier, the major purpose of EE is to develop environmentally literate citizens who have not only to acquire the necessary knowledge, cognitive skills and attitudes in the classroom, but these need to become a part of the decision-making process of the receiver throughout life. The psychology of learning and learning transfer provide a number of guidelines and generalizations for use by the teacher towards realization of the instructional objectives emerging from this goal. The transfer of knowledge and skills is most likely when

> learners acquire experience with a variety of problems. Exposure to a wide range of problems helps to develop the much needed expectancy that each problem will have to be tackled in some different way;
>
> learners learn to apply principles in situations with distracting and irrelevant elements. This is helpeful in learning transfer as they develop the ability to

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[1] Bloom, B.S.: Human characteristics and school learning, New York, McGraw Hill and Company, 1976 (Chapter II and III).

discriminate between relevant and irrelevant features of problem situations and thus the relevant principles are identified and applied effectively;

opportunities are provided for the learners to learn and use knowledge in a variety of situations, since it has been demonstrated through research that the acquired knowledge tends to be most used in the situation in which it is acquired;

if transfer is the instructional objective, the teacher must teach for transfer.[1]

For details one can refer to Gagne (1977)[2] or Travers (1963)[3] Instructional Resources: The selection of methods of teaching is also governed by the availability of instructional resources. This appears to be more of a constraint than a determinant of teaching methodologies. But it has been included in the list of determinants since the induction of educational technology, self-instructional materials and individualization of instruction has made this factor reasonably weighty in the selection decisions for teaching methodologies. For example, multimedia approaches can be adopted only if the necessary audio-visual equipment is available. Self-learning approaches can be adopted if the necessary instructional material is ensured. In the absence of adequate transport system, planning of beyond-the-school-wall experiences may be quite difficult. In this way, this factor assumes vital significance.

Organizational support

The selection of teaching methods also depend on the context of the classroom and institutional organization. Some methods can be used only if scheduling is flexible with provision for teachers to experiment and innovate with the teaching methodologies. This is all the more important in EE Curriculum transaction. The organizational support from the institution and its members is quite necessary for the effective use of these methodologies. Sometimes, even community support is needed. For example, some parents object to their wards' 'out-of-school-wall' experiences. Inquiry and problem solving methods require flexible scheduling. All these guidelines emerging from the psychology of learning and teaching have relevance for making decisions regarding the teaching methodologies to be selected for use in EE.

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1. Unesco: Strategies for Developing and Environmental Education Curriculum: A Discussion Guide for Unesco Training Workshops on EE 1980.
2. R.M. Gagne, Conditions of Learning, New York, Holt Rinchart, Winstan, 1977.
3. R.W.S. Travers, Essentials of Learning, New York, MacMillian, 1963.

Check yourself

1. I think that the four most important determinants of the teaching methodologies in the context of EE are:

   1. .... 2. ....

   3. .... 4. ....

2. The transfer of learning is facilitated when:

   1. .... 2. ....

   ....

   ....

3. From the study of the study sheet 'The determinants of teaching methodologies' the following two major generalizations can be derived.

   1. ....

   ....

   2. ....

   ....

6.2 Teaching Methodology I - Inquiry training and problem solving

OVERVIEW

Objectives

After reading the study sheet you are expected to realize the following objectives:

1. List the goals of scientific inquiry.
2. Describe rules of procedure for training in scientific inquiry.
3. Describe the five phases of scientific inquiry training.
4. Describe teacher role in scientific inquiry training.
5. Analyse a given lesson based on scientific inquiry approach using Teaching Assessment Schedule (TAS).
6. Taking up an EE problem, plan a lesson following scientific inquiry training approach.
7. Describe how scientific inquiry training can be used in problem solving.

Learning activity

Reading of the study sheet 'Scientific inquiry approach'.

Optional

1. Film, if available.
2. Demonstration of scientific inquiry training lesson, if possible.

Evaluation

At the end of the capsule, there will be questions for answering.

Study Sheet 2 - Scientific inquiry training and problem-solving

Objectives and assumptions

In the context of the EE curriculum transaction at the primary level it is important to train pupils in inquiry procedures for two obvious reasons. Firstly, the pupils gain specifics of the inquiry skills, and secondly they can gainfully utilize these skills for environment related problems. Concomitantly, pupils also learn to take positions on EE related issues.

Scientific inquiry training teaches the children how to organize information for arriving at generalizations. It helps them to establish facts, interrelate them for building concepts, deriving inferences that explain the phenomenon under inquiry. It is mostly directed at organizing knowledge with a view to explaining and establishing cause-effected relationships. The method is extensively used by creative researchers for exploring, inventing and problem solving. In short, the major goals of inquiry training are to help pupils develop the cognitive skills necessary for locating data, processing them in the light of the desired objective(s) or the problem encountered through the application of logical reasoning, hypothesizing, inferencing and testing the hypotheses.

The inquiry training is based on the assumption that pupils can be made more and more conscious of the process of inquiry which can be taught to them systematically. Another important assumption underlying the process is of inquiry generating and testing explanations (theory) if it can be further developed. Below is given a teaching encounter in the area of ecological balance based on the inquiry training approach. Read it carefully. You will be required to identify the components of inquiry training and rules of procedure, employed.

Teaching encounter

In the mountains in western India, there were numerous deer with minor fluctuations in numbers? There were also wolves in the mountains. Some people from a village witnessed a wolf pack pull down two of the small deer in the herd. The villagers felt horrified at the sight and thought that the wolves would destroy all deer. So, the villagers launched a campaign to eliminate the wolves. But their hopes were belied. The years following the elimination of the wolves showed a marked decrease in the population of the deer. Why, when the wolf is the deer's natural predator, should this occur? (Adapted from Eaggen, 1979)[1]

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[1] Paul D. Eggan, et al. Strategies for teachers: Information processing models in the classroom. New Jersey Prentice Hall Inc. Englewood Cliffs, 1979.

Teacher: Can we get some information to answer this question:

Kireet: Have other animals been seen killing deer?

Teacher: Yes, they have been.

Kireet: Different animals?

Teacher: Yes.

Sanjay: I have an idea, Sir.

Teacher: Fine Sanjay (smiles), please wait till Kireet is finished.

Kireet: Does the prey-predatory balance have anything to do with the problem?

Teacher: Can you gather some data to support that?

Kireet: Yes, let me try. After the wolves were eliminated, other predators, such as bobcats, coyotes, and large birds such as eagles, were able to prey more successfully on the deer. So their population went down. (Kireet appeared to have finished. So the teacher turned to Sanjay).

Sanjay: I have another idea.

Teacher: Good, go ahead.

Sanjay: After the deer's predators were eliminated, the population expanded. So, their habitat could not support them. They were thus led to starvation and their population went down.

Teacher: O.K., can we gather some information to support your idea?

Kipu: Were more bobcats seen in the deer's habitat after the wolves were eliminated?

Teacher: No.

Kipu: How about Coyotes?

Teacher: No.

Sherry: Were numerous barkless trees found in the region after the wolves were eliminated?

Teacher: Yes.

Kireet: Were deer carcasses found in the region after the wolves were eliminated?

Teacher: Yes.

Kireet: Before the wolves were eliminated?

Teacher: Yes.

Kireet: More after.

Teacher: Yes.

Kireet: Were the carcasses skinny?

Teacher: Some were of course.

Vineet: Were the deer in the region mule deer?

Teacher: Yes.

Kumar: Do eagles kill mature deer for food.

Teacher: Not really.

Pinki: Are the winters in the region quite cold?

Smith: Yes.

Teacher: Look at the hypotheses you have suggested and see how they fit the data.

Sudhir: I think the first hypothesis should be eliminated.

Teacher: Why, Sudhir?

Sudhir: The hypothesis suggested that other predators were the cause of the decline in population but we have found that there was no increase in the population of bobcats.

Teacher: Very good, Sudhir.

Pinki: Raised hand excitedly. I think we need to change the second hypothesis a bit.

Teacher: Go ahead.

Pinki: We found that some of the deer must have starved because emaciated carcasses were found and the trees were stripped of their bark, but we also found that some of the carcasses were diseased, which suggests that disease may have caused some deaths. I think the hypothesis should say that after the deers' predator was eliminated, their population expanded so their habitat couldn't support them and they became susceptible to starvation and disease. The wolves take the weakest members, and the herd as a whole kept healthy.

Teacher: Fine Pinki.

Alam: We do not know that the wolves do that. I know. Did the deer carcasses found before the wolves were eliminated tend to be young or old as opposed to the whole range of maturity?

Teacher: Yes.

Shah: That do sit then. That supports the Pinki's idea about wolves taking the weaker members of the population. The class was satisfied that the hypothesis was supported by the data.

You have read the teaching encounter. Could you identify the steps of inquiry? Write down the steps:

In this teaching encounter the teacher enforced some rules of procedure. Could you identify some? Write down the rules of procedure:

The teaching encounter presented above illustrates the steps for scientific inquiry. These steps are:

1. Encounter with the problem:

   This stage refers to the stage of presentation of the problem. As a first step the inquiry procedures are explained and then the puzzling event, a discrepant event, or a problem is posed as has been done by the teacher in the beginning of the teaching encounter just presented. The discrepancy of the point needing explanation is highlighted through a question which presents a challenge motivating the pupils to apply their mind to the problem.

2. Data gathering (exploration):

   The students retrieve from their memory the necessary data essential for formulating the possible explanations or hypotheses regarding the problem at hand. The teacher helps them sifting the relevant data for use through cueing and reinforcement as has been done in the teaching encounter. The initial questions posed by Kireet, Sanjay, Sherry and others were directed to this end. Through this they verify the phenomenon and conditions featuring the problem.

3. Data gathering (experimentation):

   The exercise of data collection initiated at step 2 continues with the difference that through the isolating relevant factors (variables), the pupil's formulate hypotheses (explanations), test them and try to establish cause effect relationships. In the process, the hypothesis can be revised as well, if the situation so demands in the light of the data generated through deeper insight as the process of inquiry proceeds as has been done by Sudhir in the teaching encounter.

4. Formulating an explanation

On the basis of step three, viable explanation for discrepant event can be formulated or solution to the problem enunciated.

5. Analysis of the inquiry process

The pupils analyse the inquiry process adopted by them to examine its strengths and weaknesses. Questions like - was the approach taken by us the only one or could we have considered other alternatives? Would these alternatives be better? If so, in what ways? Answers to these questions will provide for referring the inquiry process and help in searching out more effective ways of inquiry. (This step was not covered in the teaching episode).

6. Rules of procedure

The following rules emerge from perusal of the teaching encounter presented in this section:

1. The question should be phrased in such a way that they can be answered 'yes' or 'no'.

2. Once called upon, a pupil may ask as many questions as he or she wishes before yielding the floor (the teacher with a smile, politely asked Sanjay to wait till Kireet finishes when he wanted to intervene initially).

3. The teacher does not answer 'yes' or 'no' to statements of theories (proposed explanations) or to questions that attempt to elicit teachers approval of a theory.

4. Any pupil can test a theory (explanation) at any time. The following additional rules are also followed in inquiry training.

5. The pupils are allowed to confer with one another if they feel the need.

6. Inquirers should be able to work with resource books, experimental kits, if they feel like doing so.

Self Activity

You have got an idea about the inquiry training approach. Now you may select an EE problem of your choice and develop a teaching encounter following this approach.

6.3 Teaching Methodology II - Clarifying Teaching Strategies

OVERVIEW

Objectives

After reading Study Sheet 3, you are expected to realize the following objectives:

1. List at least two specific objectives of clarifying strategies in the context of EE teaching.

2. Describe at least three clarifying strategies illustrating with examples from EE teaching.

3. Design two pupil reaction sheets based on EE issues.

4. List at least three guidelines for using clarifying strategies.

Learning activity

Reading of Study Sheet 3 clarifying strategies with peers in the training.

Evaluation

At the end there will be questions for answering.

Study Sheet 3 - Clarifying teaching strategies

The complexity of the emerging society has enhanced considerably the challenge of education. In the context of environmental education, the problems and issues are emerging at a fast rate due to the effects of adequately planned programmes of modernization in developing countries and indiscriminate consumerism in the developed world. This is going to be an unending process which has been faced by the child of yesterday, is being faced today and will be faced tomorrow, as well. In such a situation it is not possible to provide to the child the requisite knowledge all along. The alternative is that he is equipped with the necessary cognitive and affective skills for the purpose. As has been pointed out earlier, EE purports to develop specific environment related attitudes and values. For this purpose value clarifying strategies can be applied to the EE curriculum transaction. Rath et all (1966)[1] has spelt out behaviours related to the development of values. The three stages of the process are: (a) choosing freely; (b) form alternatives, (c) after thoughtful consideration of consequences of each alternative. Prizing implies that the individual is happy with the choice and is willing to affirm the choice publicly. Acting involves doing something with the choice repeatedly in some pattern of life. The behaviours comprising these three stages are quite relevant in the context of EE. There are different clarifying strategies for developing these behaviours in children, some of which have been presented in this section.

These strategies have been described in this section.

The clarifying response

This particular clarifying strategy is based on the mode of responding or reacting to what a student says or does. The responding and reacting behaviours of the teachers help the students to clarify their thinking towards the specific problem or issue in hand. Examine the two episodes given below.

Episode I

Pupil: We purchased a solar cooker yesterday.

Teacher: That's nice.

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[1] S. Rath, et al. Values and teaching. Working with the values in the classroom, Columbus Ohio, Charles, E. Morrill Brooks, Inc. 1966.

Episode II

Pupil: We purchased a solar cooker yesterday.

Teacher: Are you glad that you have purchased a solar cooker? Will it be helpful to your family?

Pupil: Yes. It will.

Teacher: How will it be helpful to your family?

Pupil: It will save energy.

Teacher: That's nice. Do you think it will be helpful to you in some other ways as well?

Pupil: Yes. It will save environmental pollution.

Examine the two episodes and see the ways in which the two teachers react to the student. It will be seen that the first response, though positive, is not likely to stimulate clarifying thoughts in the pupils. But as is evident from the second episode all the questions are likely to evoke clarifying thought process on the part of the student.

The clarifying responses avoid moralizing, sermonizing, criticizing, evaluating, etc. The adult excludes prompts of words like good, right, or acceptable. On the other hand, it puts the responsibility on the student to examine his own behaviour and decide for himself what he wants. Their responses operate in the situation in which there are no right answers. Such as situations that involve feelings, attitudes, beliefs or purposes. It may also involve issues and problems, some of the clarifying responses used by the teachers as reacting behaviours are

Is this something that you prize?

Are you glad about that?

How did you feel when that happened?

Did you consider any alternatives?

Have you felt this way for a long time?

Was the something there something that you yourself selected or chose?

Did you have to choose that? Was it a free choice?

Do you do anything about that idea?

Can you give me some examples of that idea?

What do you mean by it? Can you define that word?

Where would that idea lead? What would be its consequences?

Would you really do that or are you just talking?

Are you saying that .... (repeat)?

Did you say that .... (repeat in some distorted way)?

Have you thought much about the idea (or behaviour)?

What are some good things about that notion?

What do we have to assume for things to work out that way?

Is what you express consistent with .... ?
(note something else the person said or did that may point to an inconsistency).

What other possibilities are there?

Is that a personal preference or do you think most people should believe that?

How can I help you do something about your idea? What seems to be the difficulty?

Is there a purpose at the back of this activity?

Is that very important to you?

Do you do this often?

Would you like to tell others about your idea?

Do you have any reasons for (waying or doing) that?

Would you do the same thing over again?

How do you know it's right?

Do you value that?

Do you think people will always believe that?
of 'Would Chinese peasants and African planters also believe that?'
Did people long ago believe that?
Some issues from EE fit for clarifying responses are:

It is very crowded in the streets and buses.

The food cooked in the solar cooker is very tasty.

I planted five trees in my compound.

The film I liked.

The river pollution is due to industrial waste. Select any two statements of the pupils from the above and write down a clarifying sequence that you would like for your pupils:

Sequence I	Sequence II

Pupil reaction sheet

As pointed out earlier that clarifying strategies outlined in the preceding subsection focused at assisting the students to think more clearly and independently about something which he has said or done. The reaction sheet being presented here purports to bring to the focus of the pupils some of the things relating to EE about which he has to be clear. The reaction sheet presents some of such things for the attention of pupil in a more threatening and stimulating manner. Examine the sample given below:

Directions: Below is given a news items. Read it carefully and answer the questions given at the end. Later on you will have a chance to discuss your answers with a small group of your peers.

Barauni: Yesterday fisherman went to Ganga for fishing. They cast their net as usual. After a while they recovered their nets. There were fish in the net, but strangely enough, some of them were already dead. Their colour had also changed. Other fish which were surviving also looked unhealthy. The fishermen started raising questions at each other.

1. Why had the fish died in the river?
2. Why has their colour changed?
3. Will other fish also m-et the same fate?
4. What can we do to save them?
5. What will happen if we do not take appropriate measures to prevent this phenomenon?
6. Whom do you think responsible for this?
7. Do you think that is an inhuman death?
8. Will you be a party to any action prepared for the prevention of its cause.

The children can write answers to these questions on the reaction sheet and discuss in the group.

This type of reaction sheet can be designed for bringing to the attention of pupils different problems and issues covered in the area of EE. The designing of reaction sheets can vary so far as the theme and the material are concerned. The issue can be drawn from a news item, a literary book or controversial issues concerning EE. They are, of course, based on provoking statements.

Critical incident sheet

Here the pupils are required to report, every week one incident involving this action for improving the environment (conservation, prevention of its deterioration, development of consciousness in others, etc.). During the preceding week the teacher can write down clarifying questions on the margin of the sheets for stimulating the pupil to further thinking and weigh the consequences of his actions. The design of the critical incident sheet is given below:

Critical Incident Sheet

Just like other human beings you are in constant interaction with environment. Of some of your actions relating to the environment you have a reason to feel proud. Describe in about hundred words any incident or your action relating to environment of which you can feel proud.

____

____

Teachers clarifying questions, if any ______________________________________

____

If the pupils like and they are willing to share their critical incidents voluntarily these may be read out in the class. Reading can follow discussion.

Open ended questions

The open ended questions provide the teacher with the method of getting the student to reveal some of their attitudes, beliefs and activities relating to the various aspects of EE content. Some of the sample open ended questions can be

1. My best friends in my garden are ....
2. I never pluck flowers because........................
3. I don't throw away waste in the open because..........................
4. Some people are indulging in damage to the environment when............
   ....
5. If I am asked to devote my full life for improvement of the environment I would ....

The use of open-ended questions is quite helpful because it is economical in terms of time, a teacher can write a single question on each paper or write some on the black board for students to complete. This helps the students to reflect. The teacher can read some papers anonymously to the class and ask if any class member has a question which he cares to refer to the anonymous author.

Role playing

Role playing offers a good opportunity for personalizing the actions in a particular situation. It is quite interesting to the children as they enjoy play-acting and miming. The teacher can design role-playing situations with a structure, but it is not essential. The controversial and conflict situation have a good potential for role playing. A sample is provided below.

The members of the community have noticed that some of their members put their Angithi (coal stove) in the street where smoke pollutes the air. A farmer has developed a scientific Angithi/stove in which smoke is channelled up through a chimney. Most of the community members have adopted it. Two housewives, though comparatively economically sound, do not heed to the requests of other community members. In the meeting it was decided that a group of four community members will approach the two housewives to request that they use the new Angithi in their kitchen.

Four of you who would like to approach the housewives as a team and two of you who would like to become the nagging housewives may volunteer. The teacher asks the six members of the class to come forward and sets the rule-playing situation. The roles are assigned to each of the six pupils. The others act as observers. At the end of the role playing, group discussion canbe organized around such questions as:

1. How did you feel as an actor?
2. How would you feel if observers had done things differently?
3. Would things work out that way in real life? What can we learn from the situation?

During the discussion the teacher will make use of the clarifying responses specified in the first section.

These are some of the clarifying strategies. For more, you can refer to values and teaching?

For the effectiveness of clarifying teaching strategies it is essential that the teacher build a climate of confidence, respect for independent opinions of the students on environmental issues and avoid forcing his own views on the students. The personal opinions if expressed in private or in writing should be made public or brought to discussion only with the prior consent of the student concerned.

Check yourself

1. Why are clarifying teaching strategies important in teaching EE? Give two reasons that you consider are most important.

   1. ______________________________

   ____

   2. ______________________________

   ____

2. The three stages of the process of valuing are:

   1. ______________________________
   2. ______________________________
   3. ______________________________

3. Clarifying responses avoid sermonizing because ______________________________

   ____

   ____

4. Structure four responses clarifying questions on the ecobalance.

   1. ______________________________
   2. ______________________________
   3. ______________________________
   4. ______________________________

5. Pupil reaction sheet is used to:

   (a) sensitize pupils
   (b) assess their opinions
   (c) giving information
   (d) none of the above.

   Tick ( ) the correct alternative.

6. How is role play helpful as a clarifying teacher strategy? Give two reasons.

   1. ______________________________
   2. ______________________________

7. The open-ended questions are useful as clarifying teaching strategies, because

   ____

   ____

8. Pupil reaction, sheet as a clarifying teaching strategy; should be designed around an excerpt which is ______________________________

   ____

6.4 Teaching methodologies III - Simulation and gaming

OVERVIEW

Objectives

After going through Study Sheet 4, you are expected to realize the following objectives:

1. Define simulation and gaming in your own words.
2. List the stages in operating a simulation.
3. Identify activities relating to different stages of simulation.
4. Prepare a bibliography of the simulators in the context of EE from the library.

Learning activity

Reading of the Study Sheet 4.

Evaluation:

There will be questions at the end for evaluation.

Study Sheet 4 - Simulation and gaming

There are occasions in teaching when it is not possible to provide experiences in the real life situation. For example when training a cosmonaut it is not possible to provide him real experiences of space travel. So, the real life conditions are developed in the laboratory where the cosmonaut is provided training. This training gets transferred to his performance in actual space flight. The laboratory with real like environment is a representation of actual space and thus a simulation of space conditions. Similarly, there are situations in teaching.

Where simulations are produced in the classroom itself and these situations provide the learners actual life experiences relating to the situation at hand. The social and psychological situations are created through role playing. The situations follow the model of reality. Due to active involvement of learner and direct experiencing of the real experiences result in effective learning outcomes. The elements of chance and competition make them games and the process is known as gaming. The two terms are in common use these days.

The use of simulations have three stages besides preparations.

Briefing Phrase refers to the explanations given by the controller (here the teacher) about the mechanics and procedures. The instructions can be given verbally or as written instructions. Roles and functions of each of the learners involved are also described. Briefing is followed by action wherein the participants perform their roles following the procedures and rules already explained to them.

Debriefing The concluding stage is an inquest on what happened and a discussion of points arising.

The simulations in the context of EE teaching are quite important for developing in pupils the conceptual awareness; cultural and ecological implications of the issues, acquiring competencies relating to investigation analysis and evaluation arriving at decisions in the light of values relating to EE.

National Commission on Population - A simulation*

The simulation falls in the curriculum area of social studies and can be organized at elementary or secondary level. It purports to develop conceptual awareness, cultural and ecological implication of the issues, promote investigation, evaluation of population policies in the context of ecology.

The pupils may be required to research positions on population policy before simulation. They can be provided a capsule of position examples. Synthesis session (debriefing) is to be organized at the end of the simulation to further analyse the issue and its complexities! A moderator is to be elected from the students.

Simulation

Briefing

Your government has appointed a National Commission on Population. The Commission is scheduled to hold hearings to formulate government policy on population growth in the country. The hearings purport to assess: (1) the extent of population growth in the country. (2) the factors leading to the growth of population, (3) to study the social and psychological implications of over population; and (4) the most acceptable means of influencing the rate of growth. You have been invited to appear before the commission. Your role during the hearings will be to offer expert testimony and logical arguments reflecting your position to commission members. In order to present testimony and arguments in an equitable fashion and to maintain an atmosphere of mutual respect and acceptance, certain rules need to be followed:

1. The order in which participants present their testimony will be determined by lot.

2. Each participant will be given opportunity to present his/her position and explain it fully. Following each testimony, the floor will be made available to other members of the Commission and/or witness 'to the Commission'.

3. During the discussion period, witnesses or commission members may participate only on recognition of the moderator.

4. Comments and discussion on any particular issue will be limited to five minutes and may be curtailed at the direction of the commission moderator.

At the close of the session, an attempt will be made to reach a consonance within the Commission reflecting on diverse positions for formulating recommendations to the government.

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* Adapted from Strategies of the training of teachers in environmental education. A discussion guide for Unesco training workshops on EE, Unesco 1980.

Planned parenthood expert.
Agricultural Export Economist

Religious viewholder

Pro-life activist

Environmentalist

Positions represented

Two population growth representatives.

Social psychologist

Pro-technology viewholder

Land use management expert

Other resource management experts

Others as needed.

Population growth representative

As a member of the ZPG, you advocate that your country and the world population be stabilized. Your concern encompasses a wide range of issues including early marriage, reduced family size, abortion, immigration, and controlled national population growth.

Religion representative

Your views represent the views of religious people. Over population being a serious problem, you uphold religion teaching regarding birth control, sterilization and abortion.

Action: The moderator initiates hearings. Intervenes whenever required to enforce the rules.

Debriefing: Discussion and finalization of the recommendations.

Check yourself

1. Simulation means ________________________________

____

____

2. Gaming has two additional elements, namely

(a) (b)

3. Briefing session in simulation involves ________________________

____

____

4. Action in simulation involves ________________________

____

____

5. Debriefing session in simulation purports to ______________________________

____

____

6. Simulation differs from role playing in respect of _________________________

____

____

7. Prepare a bibliography on simulation in EE from the library.

Do it

Select a simulation on EE relating to your class and run it, if possible. Write down your experiences.

6.5 Teaching methodology IV - Beyond-the-School-Wall Experiences:

OVERVIEW

Objectives:

After reading Study Sheet 5 you are expected to achieve the following objectives:

1. Give at least two reasons for providing 'Beyond-the-School-Wall Experiences' in EE teaching.
2. Describe the scope of 'Beyond-the-School-Wall Experiences' in the context of EE teaching.
3. List the steps involved in providing 'Beyond-the-School-Wall'-Experiences'.
4. Plan a field activity to realize EE objectives on a selected theme.

Learning activity:

1. Reading of Study Sheet 5.
2. Planning field work.
3. Organizing the field work.

Evaluation:

You will be required to answer to questions given at the end.

Study Sheet 5 - Beyond-the-School-Wall-Experiences - the need and scope

EE is a curricular area which permeates every aspect of human life. The ecosystem can be considered as concentric in nature in the sense that it constitutes the immediate surrounding of the classroom, the school, the community and so on. It also covers subsystems interacting with human life. So merely classroom experiences may not be sufficient for achieving the EE curriculum goals. Beyond-the-School-Wall Experiences are indispensable to realize at least some of the goals. These experiences provide to the pupils a feel of the real life experiences relating to the EE learning theme at hand.

Beyond-the-School-Wall-Experiences, cover a wide variety of activities. There can be excursions, field trips and simply field observation. Field observation forms a part of the earlier two as it is a technique to collect data for achieving the objectives of the field study. Community and ecological surveys are also covered in these experiences. Obviously, these experiences broaden the horizons of learner insight into the EE problems and issues which is essential for finding effective solutions and taking appropriate EE-related decisions. But these experiences can be effective only if they are planned systematically, implemented with a sincerity of purpose and utilized properly.

Stages

The field work to be systematic follows sequential steps. Preparation starts with an introductory talk by the teacher explaining its purpose by way of motivating the pupils. The pupils are required to contribute to the pool of questions which will have to be answered at the end of the field work. After the motivational stage of preparation, organizational details are worked out co-operatively. If necessary, pupils are divided into small groups with specific tasks allocated to them. The groups procure observation tools or log to be filled in. If not available such tools are prepared. The field trip is then undertaken. The groups and individuals carry out the assigned roles. They observe and collect data as planned. It is the experiencing stage.

It is followed by a consolidation stage where the observations and groups are presented and discussed. The positions are taken in terms of the objectives of the field work formulated at the preparation stage.

A sample of field observations

Activity

Field observation: the ecosystem concept.

Objective

The objective is at the first level relating to ecological foundations and purports to enable the pupils to study communities and the ecosystem.

Procedure

Organizing a field trip to a living system which has similarity with the ones in which we live. Walk into the system observing things around you. Don't worry if you do not know the names of some of the things in the environment. Try to focus your keen observing eye on the system from a variety of perspectives. The questions which follow will help you focus your observation to the best of your ability.

Name____________________________________

Date____________________________________

1. What would you call this living system? Is it a hardwood forest? A vacant lot? A prairie? A temporary pond? A desert? Just what is it you are observing?

2. Do you believe that this environment is dominant in the region in which you live? In other words, is this an extensive living system in the region?

   Yes______________________________No____________________________________

   Provide your reasons for answering as you did.

3. Where is this living system located? Provide some evidence as to its location.

4. Can you identify the exact boundaries of this system? What might be some of the difficulties encountered in sharply defining the system's boundaries?

5. What are the general characteristics you see when you observe the overall character of this system? If a fine drawing would help supplement your description, feel free to make one.

6. What are the non-living (abiotic) variables that seem to be controlling the character of this system? For example, what might be the influence of topography? The bed rock? Humidity? Rainfall? Air temperature? Insulation, etc. How do these abiotic factors appear to be controlling the character of this living system?

7. What population of plants and/or animals can you observe here? What is your evidence?

8. Living organisms may be referred to as 'biotic factors'. Can you identify any biotic factors which seem to heavily influence the overall character of the system?

9. Is there any evidence that layering or zones of life exist in this particular system? If so, how would you describe them? If layers or zones exist, you may wish to sketch and label these.

10. Can you observe any evidence of competition between members of a given population, e.g. between red-winged blackbirds in a marsh? Yes____________NO________
    If evidence exists, what is it?

11. Can you observe any evidence of competition between members of two different populations, e.g., between shingle oaks and swamp white oaks - or, between two different species of cacti? Yes______________ No________________
    What is the evidence?

12. What other kinds of interactions between members of different populations can you observe here besides competition? For example, a fungus plant growing on a tree stump would be appropriate. How is each organism affected by the other?

13. What evidence exists, if any, to indicate that food energy flows through the system? If you can observe evidence of this and you want to diagram it, please do so.

14. What evidence exists, if any, to indicate that this environment is more or less stable.

15. Some observers might want to apply the term 'static' to this environment. The term 'static' can be defined as showing little change, lack of animation or progression; quiescent. How do you feel about applying the term 'static' to the system? Please explain.

16. Why do you think that it is appropriate to call this system___________________ that forest_____________and pond___________________or whatever, and ecosystem? Think a bit about the term and the situation you are observing before answering.

17. (Respond to this only after completing Nos. 1-16 and when you return to class.) To what extent are your findings similar or different from those of other class members? In particular, how do other students feel about the answer to No. 16? Why?

Check yourself

1. Beyond-the-School-Wall Experiences are essential in teaching EE because (Give two reasons):

____

____

____

2. Beyond-the-School-Wall Experiences must include:

____

____

____

3. The activities relating different stages of organizing Beyond-the-Wall Experiences are:

Stages	Activities
Preparation	
Experiencing	
Consolidating	

Do it yourself

Plan a field activity in the area of EE Curriculum and organize the same. Write down your experiences about the activity:

(a) in terms of the adequacy of preparation;

(b) in terms of the effectiveness of the experience;

(c) in terms of the adequacy of organization of procedures.

6.6 Teaching Methodology V - Case-study

OVERVIEW

Objectives

After reading this sub-unit you are expected to realize the following objectives:

1. Enlist the purpose of case study as a teaching metbodology.

2. Plan case study using EE theme.

Learning activity

1. Reading of study sheet.

2. Planning a case-study.

3. Organizing a case-study with help from pupils.

Evaluation

At the end of your reading of Study Sheet 6, you will be required to answer questions and do some activities.

Study Sheet 6 - The case-study

Case-study involves collection of information about different aspects of an object, an institution, a place, an individual or a phenomenon. The scope of information to be collected is determined by the purpose for which a case-study is planned. In the context of EE Curriculum, a case-study is conducted on any component of the environment: geographical, social, biological or physical. The case-study provides opportunities to the pupils to explore, investigate, study, infer and reach a conclusion. It uses a variety of data gathering tools and techniques like questionnaires, personal interviews, field observation, etc. Its organizational procedure includes Preparation, including planning, instrumentation, and allocation of responsibilities to groups and individuals, conducting the study proper, putting the threads together through discussion in the classroom, and arriving at a conclusion. Obviously, case-studies not only make the pupils aware of the environmental problems and issues, they also develop their motivation to tackle them. The resulting sensitization may affect their environment-related values. A sample case-study will provide a good illustration.

Case-study A village[1]

Origin

There is a primary school on the edge of a village. One of the boys in class V lived about one kilometre away from the village centre. The neighbouring college was occupied by a potter who invited the boy to make something from local clay which he promised to glaze and fire for him. The boy's disclosure became a topic in the classroom and gave rise to a general discussion about other craftsmen in the village. The teacher utilized the pupil's motivation for an environmental study with a little broader scope covering various aspects of village life.

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[1] Adapted from C.J. Lines; and L.H. Bolwell, Teaching Environmental Studies, Gim and Company, Aylesbury, Bucks, 1978.

Preparation

The teacher visited the wood carvers and smithy workshop as well as the temple and made an arrangement for the children to visit the places.

Carrying out the study

The children were divided into four groups, Group one was to study craftsmen, group two to study the temple and the greenery in around the village, group three to study stone buildings and group four to study shops in the village. The groups carried out a survey, conducted interviews with craftsmen, prepared maps, carried out systematic observations, collected materials and prepared reports. The activities have been charted in figure below.

Conclusion: The work of the class was brought together by a class discussion of what had been done and an exhibition of the work done by each of the four groups.

The case study got pupils interested in the village, its life and environment. This helped in making them environment conscious and provided them insights into the problems and issues.

Consolidation activities

1. Case-study is an appropriate teaching methodology for realizing EE curriculum objectives, because
(give two reasons)

(i) ____

____

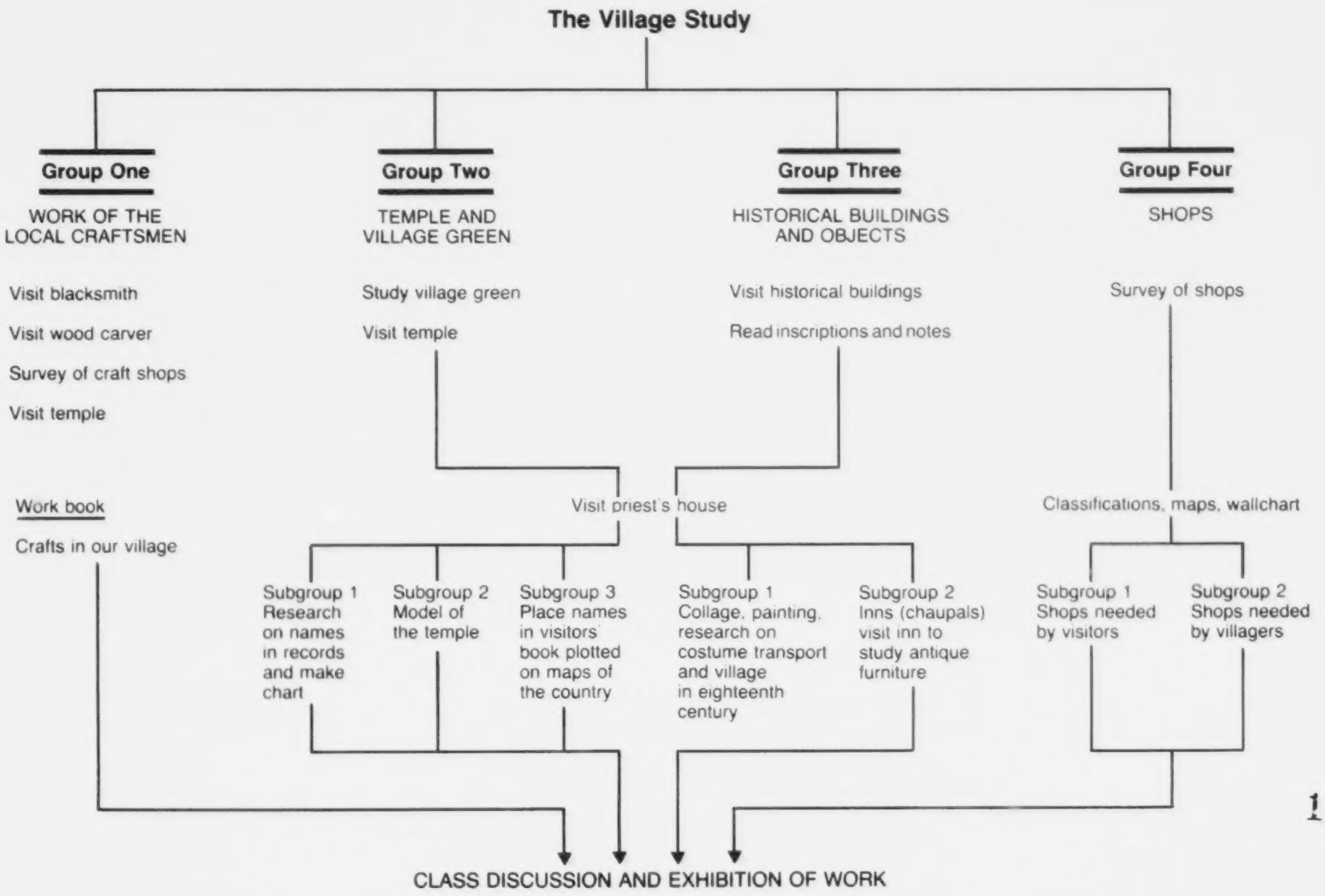
(ii) ____

____

2. Select an environmental theme and design a case-study.

In the preceding pages several methodologies for teaching EE have been presented. Their effectiveness varies with the instructional objectives to be achieved and the learner characteristics. The determinants of the teaching methodologies outlined in Study Sheet 1 presented the specifics. So, absolute values cannot be attached to the teaching methodologies. Every teacher will have to make a judicious selection of a particular methodology or a combination of methodologies depending on the nature of the teaching situation at hand. Some of the methodologies like teaching and experimentation have not been discussed in details because they are already in use in science teaching. So, the presentation is confined to more of the non-conventional methodologies suited to EE goals.

Figure 21: The Village Study


The Village Study
Group One
WORK OF THE LOCAL CRAFTSMEN
Visit blacksmith
Visit wood carver
Survey of craft shops
Visit temple
Work book
Crafts in our village
Group Two
TEMPLE AND VILLAGE GREEN
Study village green
Visit temple
Group Three
HISTORICAL BUILDINGS AND OBJECTS
Visit historical buildings
Read inscriptions and notes
Visit priest's house
Subgroup 1 Research on names in records and make chart
Subgroup 2 Model of the temple
Subgroup 3 Place names in visitors book plotted on maps of the country
Subgroup 1 Collage, painting, research on costume transport and village in eighteenth century
Subgroup 2 Inns (chaupals) visit inn to study antique furniture
Group Four
SHOPS
Survey of shops
Classifications, maps, wallchart
Subgroup 1 Shops needed by visitors
Subgroup 2 Shops needed by villagers
CLASS DISCUSSION AND EXHIBITION OF WORK

UNIT 7

7. EXPERIMENTS AND ACTIVITIES TO FACILITATE THE TEACHING AND LEARNING OF ENVIRONMENTAL DIMENSION OF PRIMARY SCHOOL SUBJECTS

7.0 Introduction

The primary school subject areas, such as general science, environmental studies, social studies, languages and arts offer ample opportunities for infusing environmental dimensions into the educational content and processes. Keeping in view the age of the learner, the instructional strategy has to be based heavily on the learner's environment to make it interesting and relevant to him/her. If teachers are oriented towards EE knowledge, skills, methods and attitudes/commitments, they can utilize such opportunities as may be available in the environment, for achieving some of the objectives of EE through the teaching of the normal primary school subjects.

This unit suggests some experiments and activities that can help the teacher to introduce environmental dimensions in the primary-school subjects. The contents of this unit are closely linked with Units 4 and 5, namely 'essential knowledge about the environment for the in-service training of primary school teachers and supervisors' and also with 'the problems of the environment and their solution'. It is assumed that the reader of this unit is fully conversant with the contents of those two units, and is now anxious to know how, or, to be more specific, through which activities/experiments a part of the EE content can be imparted to primary-school children while they are engaged in the study of their normal curricular areas.

The ultimate goal is to impart environmental dimensions to children's learning, using for this opportunities available in and around the school, thus linking all learning with the daily life experiences of children.

Before teachers start working on this Unit, it is expected that they already know, besides the essential environmental content, the history, philosophy, goals and objectives of EE, as well as the teaching methodologies in EE.

7.1 Laying foundations of EE through studies in the local environment

At the primary level the teaching has to be based, as far as possible, on the first-hand experiences of children. The local environment is the most handy resource for providing such experiences. Many concepts relevant to EE can be developed by making observations of such common things in the locality as shops, buildings, animals, and a local festival or fair.

Several skills, individually and in combination, have a special significance for EE such as (i) the skills of observation of the environment; (ii) the processing skills of problem-solving; and (iii) the processing skills of clarification of values. An activity may provide an opportunity for the development of the skills of observation of the environment. However, it should also invariably try to develop the processing skills of problem solving and those of clarification of+ values, whenever such an opportunity is available.

After going through this subunit the teacher will be able to

(i) identify situations in the local environment with a potential for developing EE concepts;

(ii) design activities for any available situation for the development of some EE concepts, values and skills.

Study sheet

A number of activities have been described here. These are based on some commonly available local situations. Study the activities carefully.

Shops

1. Go to the market-place and select a shop where articles of food or drinks are being served. Observe closely the way the food items are prepared and served, and comment on the conditions of environmental sanitation: how the articles of food and drinks are stored, whether they are covered adequately to protect them from dust, flies, ants or other insects; which practices of the workers in the shop you approve; in which way you would like to have some of these practices changed.

2. Select some other shop and find out -

   (i) how things are packaged or presented in the shop for display, and

   (ii) how the sold items are handed over to the customers to take away?

Do you think there is a wastage of materials in the packaging of articles? If yes, how would you like these practices to be changed?

3. Visit several shops where edibles are served to customers. Different types of plates - plates made of paper, plastic, metal, porcelain and plant leav may be used for serving food articles. Which one do you think is the best from the points of view of hygiene, sanitation and conservation? Give arguments in support of your view.

4. Investigate and make an inventory of the different types of things sold in the local market. What are the items produced locally and which ones are brought from outside? Classify them into plant and animal products and non-living products. Which of them are agricultural and which ones are manufactured?

Animals

1. Look for animal life in the locality. The animals may include birds, insects, domesticated animals, fish, human beings, etc. Prepare a display chart to show the variety of animal life.

2. Observe animals of the locality to note the type of food they take. Look for evidence for a possible food chain in the biological community of the local environment.

3. List names of a few domesticated animals in your locality (e.g. cow, dog, hen, parrot). Talk to the owner of the animal about the care and feeding of the animal. Also discuss with him the fodder problem that he may be facing.

Buildings

1. Examine the types of buildings in the locality. Make sketches of the buildings, say of a school, a hospital or a residential house. Select any one building and identify the materials used in its construction. Record your observations in the table given below.

Sl.No.	Name of the material	Use/purpose	Source of supply	Problems
1.	Wood	Windows, doors, etc.	Forest trees	Deforestation/ any other
2.				
3.				
4.				
5.				

2. Examine the building of your school or house and find out the system of water supply and drainage. Are you satisfied with the methods of storage and use of drinking water? If not, make suggestions for improvement.

Local festival/fair

Visit a festival or a fair where a big gathering is celebrating something. Closely observe and record your observations on problems that arise on such an occasion, e.g. problems of human behaviour and those regarding undesirable food and environmental sanitation (wastes disposal and water supply) practices. Suggest what measures you would undertake to solve such problems.

The family

Visit five families in your locality. Collect information from each family on the following:

family size
number of school/college-going children
earning members
dependent members
number of rooms in the house
percentage of income spent on food
number of malnourished children, if any
garbage disposal procedure
water supply (quality of water)
food habits

Comment on the above information with your suggestions for improvement.

The teacher trainees may actively perform these activities if such situations are available. They may be required to identify some more situations, in their local environment, which have a potential for developing EE concepts, such as, the interdependence of the natural and cultural worlds, and the finiteness of natural resources. They may spell out problems in respect of such aspects as health and nutrition, recreation and work environments. They may discuss these problems and design activities to fulfil the objectives of EE.

7.2 Understanding environment and environmental problems

This sub-unit provides activities and experiments to develop awareness and understanding of environment (Unit 4) and environmental problems (Unit 5) such as abiotic and biotic components of the natural environment; environmental resources; environmental problems of pollution, soil degradation and disruption of balance; problems of socio-cultural environment, faced by underdeveloped countries, such as nutrition, health and environmental sanitation.

7.2.1 Abiotic environment - seasons and climate

Activity: Weather conditions in relation to latitudes.

Go to the library and see the files of old newspapers for information on weather conditions. Select any three places or cities with different latitudes. Calculate average values of (i) maximum and minimum temperatures, (ii) humidity, (iii) duration of the daytime for the months of January, April, July and October. Are the variations in temperature and humidity related to the latitude of the place? Discuss.

Activity: Impact of weather conditions on living things.

(a) Take up a project for the study of variations in weather at your place during any month. Record your observations in a chart as suggested below:

Study of weather conditions at ____________ during ____________________ 1984.

Date	Temperature		General conditions			Remarks
	Max.	Min.	Sunny/cloudy	Wet or dry	Windy or calm	
1						
2						
3						
4 etc.						

(b) Make such weather charts for different months of the year. How many seasonal variations do you recognize? Describe how these seasons differ from one another. Are these variations related in any way with the duration of daytime?

Describe how the changes in weather conditions influence the activities (e.g. dress, food, recreation) of the local people. Extend your observation to plants and animals (e.g. flowering season, fruiting season, seasonal differences in animal populations).

7.2.2 Biotic environment

Activity: Diversity of plants

Observe carefully different plants including trees growing in and around the school campus. Study the differences in height, silhouette (shape in outline), shape of the leaf, flower and fruit. Record your observations giving brief descriptions and drawings. Make collections and display the same.

Activity: Diversity of animals

Observe carefully different types of animals living in and around the school campus. Record the following information about each animal:

(i) the name and a sketch

(ii) habitat

(iii) its food

(iv) its predator (if any)

(v) its relationship with man.

Classify these animals on the basis of their food.

Activity: Animals' life on a tree

Go to any big tree. Observe closely the animals living on it. You may find them on the trunk, underneath the bark, on the branches, among the leaves, etc. Record your observations as suggested below.

Study of the animals found on the__________ tree

S.No.	Type of animal	Animal's activities	Where it lives on the tree	How it is being helped by the tree
1.	Birds			
2.	Squirrels			
3.	Insects (adult)			
4.	Caterpillar			
5.	Spiders			
6.	Any other (specify)			

Activity: Animals help the plants

Study some animals that help the plants in your locality. Go around and look for situations in which animals help the plants. Some examples:

(i) Birds, bees and butterflies help in pollination, which is necessary for the formation of seeds.

(ii) Birds help in the dispersal of seeds and fruits.

Collect data of your observations and give a brief description along with diagrams.

Activity: Interdependence of plants and animals

Take three small bottles and mark them 1, 2 and 3. Collect some pond water, a submerged plant like Hydrilla and a few small pond snails. Fill the bottles up to the brim with the pond water. Put a Hydrilla twig in Bottle 1, a pond snail in Bottle 2, and a pond snail and a Hydrilla twig in Bottle 3. Make the bottles air tight by sealing them with wax and keep them in the open. Observe the bottles for a week or more. What differences do you observe in the three bottles? Do your observations support the statement that plants and animals are necessary for the survival of each other? Discuss.

7.2.3 Ecosystem

Activity: Aquatic ecosystem in an aquarium

Have a leak-proof container of about 20-litre capacity. You may use a carboy, a wooden tub, a bucket or even a barrel cut into half. Wash some sand repeatedly with water and dry. Spread evenly a 2.5 cm thick layer of this sand at the bottom of the container. Carefully pour tap water or water from a well, spring, stream, or pond over the sand to a reasonable height. Water from natural sources may contain numerous organisms. It would be interesting to have them in the aquarium. Cover the vessel with a lid to prevent excessive loss of water by evaporation.

Plant some aquatic plants (Elodea and eel grass) in the sand. Some algae may also be added, especially if water from a pond, spring or stream is used. These plants are good oxygenators and also serve as food for the animals. Avoid using a dense mat of plants. This may lead to insufficient light and retard photosynthesis. Place the aquarium near a window where sufficient sunlight is available. Alternatively, use electric light.

Fish of different kinds are now introduced into the aquarium. Feed the fish regularly once a day and observe their activities.

Make observations on the aquarium for a number of days. In a balanced aquarium you can observe:

(i) the growth in the plants with new roots and leaves;

(ii) chains of bubbles escaping from some of the plants;

(iii) various activities of the fish.

Set up a balanced aquarium as an ongoing project for observation on such diverse aspects as (i) the dependence of animals directly or indirectly upon green plants for oxygen and food, (ii) the relation of carbon dioxide and light to photosynthesis, (iii) food chain.

Activity: Pond ecosystem

Visit a fresh water pond for a detailed study of its ecosystem. Observe and identify the different types of plants and animals available there. Look for inter-relationships between plant life and animal life and the abiotic environment. Record your findings and give a brief description and suitable drawings wherever necessary. Collect the specimens you would require for future study and identification.

Tick the plants/animals you could identify in the tables given below:

(a) Study of plant life in the pond

Moist soil beyond the edge of water	Waterlogged ground at the pond's edge	Surface of water	Pond's bottom
Grasses	1.Arrow-heads 2.Cat-tails (Typha) 3.Spike-rush (Eleocharis)	1.Phytoplankton (chiefly algae) 2.Unattached floating plants such as - Wolfia - Salvinia - Pista - Lemna - Azola	1.Filamentous alga attached to bottom e.g. chara. 2.Rooted submerged plants e.g. - Hydrilla - Vallisnaria - Ceratophyllum 3.Rooted plants, e.g. - Indian lotus (Nelumbo incifera) - Water lily (Nymphea) - Singhara (Trapa)

(b) Study of animal life in the pond ecosystem

Name/Type of the animals	Places where seen	Observed behaviour/ relationships	Remarks
1.Zooplanktons			
- ciliates			
- flagellates			
- other protozoa			
- rotifers			
- small crustceans			
- eggs of various aquatic animals			

Name/Type of the animals	Places where seen	Observed behaviour/ relationships	Remarks
2. Insects or insect larvae e.g.			
- water boatman			
- water scorpion			
- water strider			
- dragonfly nymphs			
- mayfly			
- mosquito larvae			
3. Benthoic animals e.g.			
- snails			
- mussels			
- prawns			
- crabs			
- worms			
- nydra			
4. Vertebrates e.g.			
- snakes			
- birds, such as heron, cranes, kingfishers			

Activity: Food chain in an ecosystem

Survey your locality and identify an ecosystem for the study of food chain. Find out the organisms at different trophic levels. Observe the organisms closely and find out 'who eats whom', and construct a food chain operating in the area. For example, in a desert ecosystem you may find:

Grass → Grasshopper → Frog → Snake → Peacock (Refer to Unit 4)

7.2.4 Environmental resources

Activity: Energy for cooking

The resources of the human society for its sustenance are both renewable and non-renewable. Survey your locality and cite examples of the above two types of resources in respect of the energy needs for cooking. Record your observations in the table given below.

Study of energy resources for cooking in our locality

S.No.	Energy resources for cooking	Number of families using it	Procured		Local environmental implication (extent of use in the locality) and constraint
			Locally	from outside	
1.	Fuel wood				
2.	Cow-dung cake				
3.	Kerosene				
4.	Coal				
5.	Biogas/LPG				
6.	Electricity				

Activity: Materials of common use

Survey your locality to prepare a list of items of common use in the community. Mention against each item the materials (e.g. metal, clay, porcelain, plastic, wood, etc.) of which these things are made. Mention which of these materials are replenishable and which ones are non-replenishable. Discuss environmental implications of the practices associated with the use of these materials.

Activity: Recycling of used materials

Find out if there are any practices in the community associated with the recycling of used materials. Does the community practice 'recycling' of used paper to prepare new paper or some other article? If yes, give a description. Consult library to gather more information on the recycling of 'used paper for a fresh use'.

Activity: Conservation of soil and water

Take three trays made of wood or metal, exactly of the same size. They should have an outlet at the bottom for collecting the runoff. Fill the trays to the same level with various soils (e.g. sand, clay, and humus). Sprinkle carefully a measured amount of clear water over each box everyday. Collect and measure the volume of runoffs everyday. Find out:

(i) which soil produces the maximum runoff?

(ii) which soil gives a runoff with maximum of sediment?

(iii) which soil retains moisture best?

(iv) which soil gives a runoff which remains as a 'suspension' the longest?

Plant various types of seeds in the soil. When there has grown a vegetation cover, repeat the experiment of sprinkling water and measuring the runoffs. What are the noticeable differences as compared to soils without a vegetation cover? Are the vegetation covers from different seeds equally efficient for checking soil erosion?

Discuss possible reasons for any differences. (You may refer to sub-unit 5.1.4 'Vegetation cover inhibits erosion'.

Activity: Sources of water supply

Make a survey of your village/locality and note the sources of water, which the community uses. Prepare a chart and note against each water source, if it is: (a) a kachcha well, (b) a pucca well, (c) a pumped well, (d) a covered well, (e) a deep well, (f) a step well, (g) a pond, (h) a canal, (i) a stream, (j) a spring, (k) any other.

Observe each source of water and note the purpose for which its water is used.

7.2.5 Pollution

Activity: Air pollution

Select areas such as the following for the study of the problem of air pollution. These areas should have trees, preferably with broad leaves:

(i) a coal-powered factory,

(ii) a railway station, or even railway track,

(iii) a road,

(iv) a textile mill,

(v) a cement factory.

(a) Collect leaves (say, ten from each area) from the trees growing in each of the areas selected for study. Put the leaves from each area in separate polythene bags and bring them to the laboratory. Wash the entire dust from the leaves of each bag in separate Petri dishes, using a camel brush. Let the water evaporate. Observe the dirt/dust in each Petri dish under a microscope. Note any differences in the size and shape of the particles. Discuss it in the light of the nature of the polluting source.

(b) In any one area, collect leaves from different trees in separate polythene bags. The trees should be at different distances from the polluting source. Follow the procedure as described in the previous activity. How is the amount of dust obtained from the leaves of different trees related with their distances from the polluting source.

Activity: Pollution of well water

Visit a village well. See if its surroundings are clean, or if there is a lot of waste water accumulated around it. What are the causes of the accumulation of the waste water? How can we remove these unhygienic conditions?

Observe if the well water is being polluted by some agency, e.g. falling leaves, decaying organic matter, animal excreta, etc. Is there a garbage and waste disposal site in the vicinity of the well? How can this pollution be checked? Suggest measures.

Activity: Industrial pollution of water

Visit an industrial site. Any chemical industry like paper-making which uses a lot of water will be the best for observation. See how the effluents from the industry are disposed of.

Do they pour the effluents into a river? Collect some polluted water. Smell, and test it with pH paper.

Activity: Effects of water pollution on fish

Set up four aquaria using four different samples of water to fill the tank, viz., (i) tap water, (ii) pond water, (iii) water with some detergent, and (iv) water polluted with the effluent of some industrial plant. Test with pH paper and note the value of pH in each case. Put a few fish in each of the aquaria. Observe the behaviour of the fish. Discuss your observations in the light of water pollution problem.

Activity: Use of banned pesticides

You know that some pesticides have been banned, withdrawn or severely restricted for use in various countries, such as, DDT, BHC, methyl parathion, heptachlor, lindane.

Survey your locality. Find out the names of pesticides that are commonly used. Are the pesticides listed above also being used? If so, find out the extent of their current consumption and the area they cover. Suggest what can be done to remedy this problem.

(Refer to Unit 5)

Activity: Ill-effects of the use of fertilizers and insecticides

You are aware that in spite of the selective capacity of the organisms, which is limited, many harmful substances like the residual breakdown products of pesticides and fertilizers are taken into the body of the organisms, deposited and transferred to consumers, causing a threat to the continuation of life.

Make a survey of your locality to find out the names of fertilizers and insecticides commonly used by the people. Inquire from elderly people about the occurrence of any ill effects which are associated with the large-scale use of these fertilizers and insectivides.

(Refer to Unit 4)

7.2.6 Soil degradation

Activity: Soil erosion

Take two empty boxes and label them as A and B. Fill them up with soil. In box A, put some freshly cut turf obtained from a field. Keep the other uncovered as such. Put the two boxes in the open. Pour water on both of them. Compare water that is washed away from A with that washed away from B. What difference do you notice in the two cases? How does it explain that careless cutting of trees and removal of the vegetation cover lead to soil erosion?

Activity: Factors promoting soil erosion

Survey your locality and find out places with definite indications of soil erosion. Find out what possibly are the causes of this soil erosion: overgrazing, felling of trees, clearing of the vegetation cover. Discuss with elderly people how they feel about the cause of the soil erosion. Suggest measures to check the spreading of soil erosion to more areas.

Activity: Waterlogging

Survey your neighbouring area to locate places where the land is waterlogged. Have an experimental plot to try its reclamation. Try any one of the methods given in Unit 5.

Activity: Soil salinity

Take a walk in the fields and observe the top soil. You may find whitish patches on the soil. Pick up some of the whitish substance and feel it. Shake some of it in water. Is it acidic or alkaline? How does this salt deposit come on the surface of the soil.

What is the extent of salination of soil in your locality?

Study the soil salinity problem in your locality. Select four experimental plots to study the relative effectiveness of different methods of removing salinity such as (i) leaching/irrigation with provision of adequate drainage; (ii) addition of chemical amendments, (iii) green manuring.

(Refer to Unit 5)

7.2.7 Disruption of balance

Activity: Ecological imbalance in an aquarium

Set up four, more or less identical, small balanced aquaria. You may use four side-mouthed bottles or battery jars. Clean them well. Put a layer of sand (well washed and dried) at the bottom of these containers. Plant some aquatic plants (Elodea, eel grass, algae, etc.) in the sand. Fill the jars with water poured over a piece of paper to prevent the sand from being disturbed. Make identical arrangements for providing light to the four jars. Introduce a few fishes in the jars, feed the fish regularly. Observe for a few days to see that plants and animals are surviving well. Now make the following changes and study. (i) In one aquarium make promiscuous additions of fish, tadpoles, crayfish, dragonfly and nymphs. Study the effect on the organisms of the aquarium. Add to the population of any kind of animal to make it overpopulated. Observe the serious effects and record. (ii) In another balanced aquarium add excess of algae or other aquatic plants. Observe the effects and record. (iii) In another balanced aquarium change the physical conditions, e.g. light and temperature. Observe the effects and record.

You will find that the experiment of the unbalancing of an aquarium by changing physical conditions (light, temperature, chemicals, etc.) or by introducing new plants or animals or by adding more members of the plants or animals already present in the aquarium, helps in understanding the ecological relationships.

7.2.8 Nutrition, health and environmental sanitation

Activity: Spoilage of food

Take a large potato or bread. Cut a piece and put it in an open container. Keep it in a dark place. Moisten it from time to time. Observe any changes for a number of days. Do you notice different colour and smell? Do you find some cottony growth? The cottony growth is due to organisms called moulds.

Similarly observe changes for a number of days in milk kept in three glass tumblers. You will observe typical smell but no cottony growth. This is due to the activity of very small living things (about one-thousandth of a millimetre) called bacteria. Some other very tiny organisms causing spoilage of food are yeasts, protozoans. They are commonly called microbes. Some microbes are even useful to man. Can you mention a few? (the green mould that produces penicillin, bacteria that change milk into curd).

Activity: Wastage of food

Examine your own behaviour as well as that of your family members while taking meals. Is there a wastage of food due to spilling while the food is being eaten or served? Is some food left uneaten in plates? Is there a wastage of food because of faulty cooking procedures? Is there the problem of improper storage of food so that it is eaten by rats and insects? What are your personal habits that lead to wastage of food? What can you do to change your habits?

Activity: Meeting nutritional needs from locally available foods

List in the table locally available foodstuffs that are rich in proteins and vitamins A and B.

Table: Locally available foodstuffs

S.No.	Food rich in protein	Food rich in vitamin A	Food rich in vitamin B
1.			
2.			
3.			
4.			
5.			
6.			

Which of the foodstuffs listed by you are comparatively costly and therefore beyond the reach of the poor people. Suggest some cheap substitutes.

ACtivity: Prevalent diseases in the community

Visit 15 families in your locality to find out the ailments they have suffered most. Inquire specifically about common infections among children such as diarrhoea, dysentry, worms (round worms, hook worms, thread worms), typhoid, fever, malaria, common cold, pneumonia, whooping cough, etc.

Find out the diseases that are prevalent in:

(a) summer months,

(b) rainy months,

(c) winter months,

(d) or throughout the year.

Activity: Environmental sanitation problems in the community

Make a survey of your locality. Find out how the garbage is disposed of by the different families. Do you find any family throwing the garbage outside the house? Do you find a lot of houseflies and mosquitoes at such places? Discuss how these flies and mosquitoes would affect the health of all the families living nearby. How can we manage to keep the surroundings clean? (The garbage should be collected in a can which should be kept covered.)

7.3 Environmental action

This sub-unit provides exemplar activities to develop understanding, attitudes for commitment, and skills for environmental action relevant to unprivileged societies. The activities are selected from priority areas and will, if carried out enthusiastically, promote the environmental status. For example, the disposal of waste by making compost, and keeping the source of potable water safe will improve environmental sanitation. Rehydratation measures will check diarrhoea which is a killer disease. Foods can be protected from wastage through spoilage, and damage by rodents by some methods which have been used in some activities. There are activities on food preservation as well. Papaya plantation in homestead can supply valuable nutrients. The activity on social forestry can re-establish the vegetation cover.

7.3.1 Environmental sanitation

Activity: Preparation of compost

Select a site where rainwater does not accumulate. Dig a pit measuring about 3x2x0.85 m. Collect waste materials, such as straw, sugar-cane refuge, fallen leaves unutilized animal food, crop residues and garbage. Deposit them in the compost pit in layers of 23-25 cm from the bottom of the pit. Put a thin layer of soil after every two or three layers of plant and animal residues. This way fill the pit up to the top. The filling may take about four months. Add water from time to time. Cover the pit with soil in such a manner that rainwater does not percolate directly into the pit.

After one month remove a small portion of the earth-cover of the pit. Add water if there is insufficient moisture inside the pit. Close the pit with a paste of cow-dung and soil. After about six months the compost is ready for use.

Use this compost for plants in the school courtyard or kitchen garden. Do you find any noticeable differences? Discuss.

Activity: Keeping the source of potable water safe

Visit a well in your locality, which is used by the people as a source of potable water. Closely observe the well while in use. Record your observations, especially on the following aspects:

(i) Are clean buckets being used to draw water from the well?

(ii) Is a bucket used for washing clothes and cleaning utensils, also used for drawing water from the well?

(iii) Is the well covered so that leaves, twigs, etc., are kept away from falling into the water?

(iv) Is there a drain to draw waste water away from the well? Or, is there a lot of waste water collected around the well?

(v) Are the surroundings of the well clean and hygienic?

(vi) Is there any urinal, latrine or garbage disposal site near the well?

Prepare a list of dos and don'ts to keep the well water clean and safe. Implement them in the community through a suitable follow-up action.

7.3.2 Health

Activity: Rehydration to check diarrhoea

Survey your locality to find out if there is a child suffering from diarrhoea. The child would lose water and salts from the body because of watery stools and vomiting. To check this condition of dehydration, prepare a special drink as suggested here.

Add 3 grams (1½ teaspoonfuls) of salt and 25 grams (5 teaspoonfuls) of sugar to 1 litre of safe water. Add a pinch of sodium bicarbonate (edible soda) to enrich the solution. Give this drink to the suffering child. How does he feel after the drink? Do not keep this drink for more than 24 hours.

7.3.3 Nutrition

Activity: Preservation of food

(a) By drying

Take raw mangoes, cauliflowers, cabbage, brinjals, etc. Wash and cut them into pieces. Put them in a tray and dry them completely in the sun. Keep them in a clean dry glass or tin or plastic container. Taste one piece each day for a number of days. Do they get spoiled on keeping them as such.

(b) By salting

Take some mangoes, cauliflowers, turnips, carrots, chillies, lemons, etc. Wash and cut them into pieces. Mix salt well with the pieces. Spices like fenugreek, turmeric, pepper and chillies may also be added. Some oil (mustard oil, or rapeseed oil) is also mixed. The entire mixture is filled in glass or porcelain containers. After a few weeks the preserved items known as pickles are ready for use.

(c) By keeping in sugar syrup

Take mangoes, amlas or carrots. Prepare some sugar syrup by adding sugar to boiling water. Boil it for some time. As the syrup is being prepared, wash the fruits and cut them into pieces. Add these pieces to the syrup and boil for some time. Cool and keep them in a glass, tin or plastic jar. The fruits do not get spoilt for quite some time.

Activity: Preparation of milk from groundnuts

Take fresh groundnut pods. Remove shells. Roast the nuts gently for five to ten minutes. Rub off the pink skins. Soak one cup of white nuts in clean and safe water for two hours. Throw away the water and grind the soaked nuts to a fine paste.

Add five cups of water and stir vigourously for five minutes. Filter it through a piece of cloth. Boil the milky liquid and keep stirring it. Boiling will improve the flavour. Cool the liquid and remove the skim of fat from the top. It can be sweetened and used as milk for children where milk is scarce.

Activity: Prevention of food wastage in cooking

Cut two or three apples into small pieces. Use sufficient amount of water to boil the apple pieces for 20-30 minutes. Strain out the apple pieces and collect the liquid in a clean tumbler. Taste it. Why does this watery liquid taste so fine? Do you think the apple pieces have lost some food constituents to the water in which they were boiled? Why is it necessary to consume this water instead of throwing it away?

Activity: Eliminating rats from households

Collect different types of rat traps available in the locality. Use them to trap rats in your household. Which one of them works best? Do you think such traps can be used for the elimination of rats from a field? Suggest an alternative way.

Activity: Rodent control among standing crops

Prepare pea-size, non-poisonous tablets out of a mixture of wheat flour (2 kg), vegetable oil (200 gm), and juggery (200 gm).

A poisonous bait material can be prepared by mixing zinc phosphide (50 gm), wheat flour (2 kg), vegetable oil (200 gm), and juggery (200 gm).

All burrows in the field are located and sealed with clay. On the next day the burrows that are found open are marked. These open burrows indicate the presence of rats. Two to three tablets (10 to 15 gm) of the non-poisonous bait material are put on a piece of earthern pot and placed inside the burrow at a depth of about 10 to 15 cm. The burrow is sealed with clay. All the open burrows are treated in this way. This procedure is repeated on the following day for all the open burrows.

On the next day all the open burrows are treated with poisonous bait material (about 10 to 15 gm for each open burrow). Dead rats found on the next day are buried about two feet in the earth. The above treatment of open burrows may be repeated with aluminium phosphide tablets.

As a follow-up action, make a survey of the field again after one or two months. Has the rodent problem again cropped up? If yes, what are the possible causes? What measures would you suggest to further check the problem?

Activity: Cultivation of papaya tree for nutritional requirements

Select a plot with well-drained deep loans. Apply a good quantity of farmyard manure or compost to the plot. Plough twice during April-May. Break the clods and level the field. Dig 50x50x50 cm pits for papaya plants maintaining a distance of 2.5 to 3.0 metres between plant and plant, and row and row. After two weeks fill the pits with a mixture of 1 kg of bonemeal or 250 gm of superphosphate, three basketfuls of compost and one basketful of soil.

After the onset of rains sow three seeds of papaya in the centre of each pit. When the seedlings are 12 to 15 cm tall, remove the weaker seedlings to maintain only one healthy plant per pit. Irrigate properly if there are no rains.

When ripe, the papaya can be given to children regularly for eating. Find out the impact of this change in the food habit.

7.3.4 Social forestry

Activity: Growing trees for a hygienic atmosphere

This activity, besides creating a hygienic atmosphere in schools and villages, would help pupils and teachers develop skills in growing trees. To some extent, the activity may meet the nutritional requirements of children, fuel need, and even fodder requirement.

Select a site for planting trees in the school compound. Dig required number of pits during October/November and allow the dug-out soil to remain around the pits for two or three months. Mix 5 kg of compost or farmyard manure with the soil per pit. Just before the start of monsoon fill the pits with the soil. Procure saplings of trees (e.g. jamun, mango banyan, neem) and plant them in pits carefully. Fence the plants to keep them well beyond the reach of goats and other animals. Water the plants at proper intervals. Continue the after-care, including manuring and protection, till the plants are quite tall and strong.

7.4 Environmental games and other follow-up activities

It is crucial to introduce environmental concepts at the primary level in such a way that they are meaningful to children. Activities and experiments help them to develop some understanding. However they need the support of follow-up activities for the consolidation of concepts. If games related to EE concepts are designed and implemented, the children's active participation will be fully assured. The following game is an example of an activity which would encourage pupils' participation and their use of creative skills.

Activity

Select an area of the school compound for this game. Scatter some quantity of seeds or grains on the ground. Allow ten children to pick up as much 'food' as they can in the selected area within two minutes. Make a record of how many grains each child procures within the stipulated time.

Repeat the exercise using the same quantity of 'food' (seeds or grains) but with 20 children participating in the game. Make a record of the number of grains picked up by each child in the game-time of two minutes. Repeat the game twice more with 30 and 40 children respectively.

Find out the average number of grains/seeds procured per child in each of the four games. Discuss how an increase in the number of children affects the procurement of food by individuals.

Besides such games, teachers can also write dramas highlighting such themes as nutrition and health, environmental sanitation, or infectious diseases. Children would enjoy playing such dramas.

7.5 Check yourself

1. List as many cases as possible which are illustrative of a 'food chain' in your local environment. Also cite an example of a 'food web' operative in your environment. Write a brief note on examples of plants and animals functioning at different trophic levels in your environment.

2. Devise a game that would help children learn and remember the information about some common communicable diseases (e.g. the name of the disease, its symptoms, its cause and the preventive measures).

   (The teachers may devise a game of matching cards in which one set of cards indicates the names of diseases and the other set gives the symptoms of diseases. One who matches the names of the diseases with the symptoms correctly in the shortest time is to be deemed to be the winner.)

3. Write a drama highlighting the importance of vaccination/inoculation for the prevention of some diseases.

4. Design activities based on the 'aquarium' to illustrate the following concepts/ principles:

   (i) Our Earth as a closed system.
   (ii) Effects of overpopulation.
   (iii) Pollution.
   (iv) Disposal of wastes.
   (v) Ecological balance.

UNIT 8

8. EVALUATION IN EE TEACHING

8. Introduction

Curriculum evaluation has been covered separately in Unit 9 on Curriculum Development, Evaluation and Management. Here in Unit 8 focus has been given on evaluation in the specific context of EE teaching. Several questions arise in this respect. What should be the scope of evaluation in EE teaching? What mode of evaluation is suited to the needs of a multidisciplinary infusion model applied to the EE curriculum and its transaction? What are the tools of evaluation that can be used? How can evaluation data be used for improving the effectiveness of EE teaching? These are some of the questions which receive focus in this unit of the module.

OVERVIEW

Objectives

After reading this unit the teachers are expected to achieve the following objectives:

1. Describe at least two implications of the EE curriculum focus for evaluation in about 50 words each.

2. Describe in about 50 words each the function of evaluation in EE teaching as:

   (a) feedback mechanism for improving teaching,

   (b) diagnosing pupils' learning difficulties,

   (c) means of evaluating pupils' progress.

3. List the tools to be used in EE evaluation and describe at least two situations each in which they can preferably be used.

Learning activities

1. Reading of the study sheet 'Evaluation in EE Teaching'

2. Doing the suggested activities.

Evaluation

After reading the study sheet the teachers will be required to answer questions given at the end.

8.1 Evaluation in EE Teaching

8.1.1 Evaluation focus

EE as a curricular area has unique characteristics of its own. It follows the multidisciplinary infusion model of the curriculum. The objectives of this area are much wider in scope as they not only cover knowledge and awareness, skills and values, but are action oriented. Matching the objectives, the teaching methodologies employed in transacting the EE curriculum also have a variety. Evaluation in EE teaching should also match the unique characteristics of this curricular area, its specific objectives and the teaching methodologies employed to achieve the stipulated goals.

Three major functions of evaluation in EE teaching should be kept in view. First, it should help in evaluating the pupil's progress at different stages of teaching. Secondly, it should help in diagnosing the pupil's difficulties in learning. Thirdly, it should serve as a mechanism for improving teaching. The three functions are not mutually exclusive. They are interrelated and interdependent with a lot of overlapping. For example, a pupil's progress may point to the strengths and weaknesses in his learning, the diagnosis may provide the cause of shortfall in learning, which may in its turn, provide guidelines for modifying teaching strategies so as to effect better learning in pupils. The three functions have, however, been analysed as three separate components for the convenience of understanding. The three functions imply that evaluation in EE is a continuous activity and is to be conducted at different stages of teaching. This type of en route evaluation is also termed as formative evaluation, which forms a feedback based mechanism for regulating teaching procedures adapted to the needs of pupils. The final evaluation is termed as summative evaluation. It provides an estimation of the outcomes of teaching in terms of pupils' attainments. The focus of evaluation in EE teaching is on the degree to which the pupils are achieving the objectives of a particular lesson, unit or module. This assessment requires measurement of some kind. The type of measurement and tools of measurement depend on the objectives to be assessed.

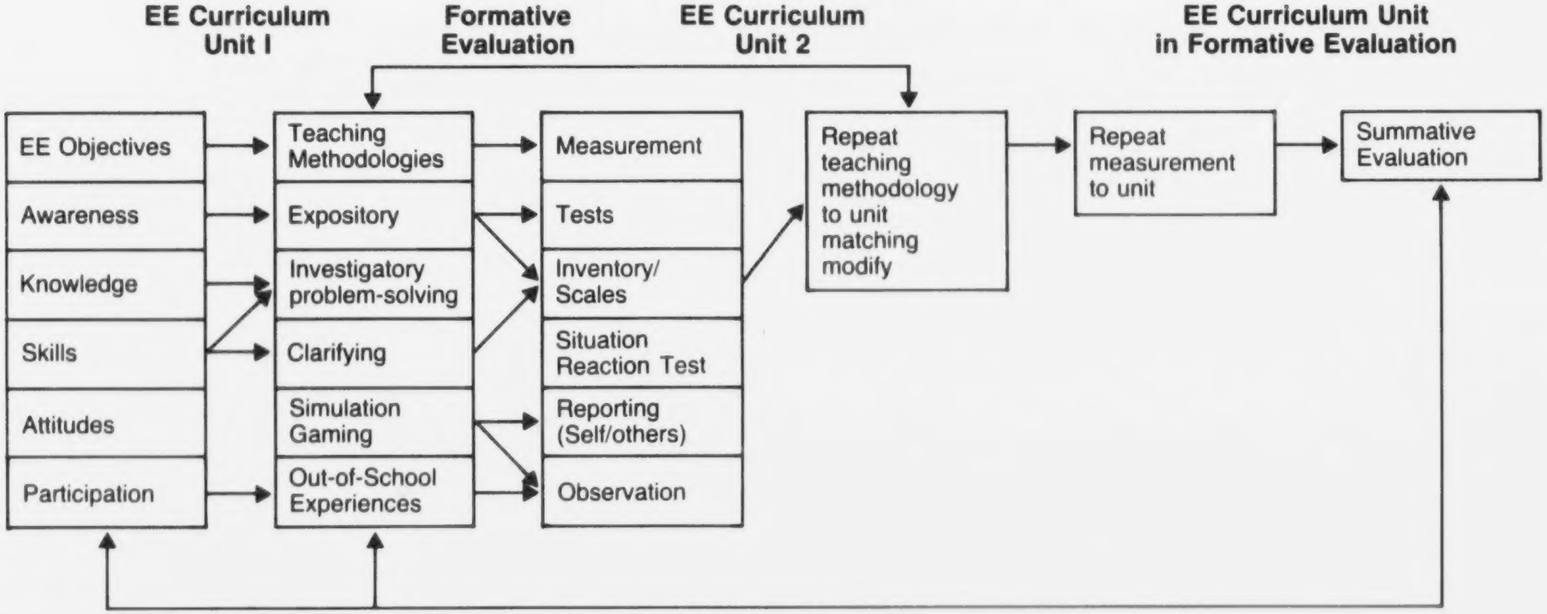
Though the non-formal nature of EE learning puts limitations on evaluation, yet reliable and valid measurement is indispensable to assess pupils' progress and use the data for the improvement of pupils' learning in the EE curricular area.

The process of evaluation in EE teaching, its components and its utilization have been conceptualized in Figure 22. It illustrates how the EE teaching objectives, methodology and evaluation match. It also indicates feedback loops at the bottom of the figure, which provide guidelines for modifying the match, if necessary, as indicated by arrow in the upper part of figure.

8.1.2 Evaluation note

Figure 22 stresses the need for matching the EE objectives and the mode of evaluation. The non-formal nature of EE learning in a variety of situation, particularly in out-of-school situations, puts limitations on structured and perfect goal-oriented evaluation. For example, assessing the attainment of EE objectives requires some form of measurement. Measurement, in the scientific sense, is the process used to determine the degree to which the learners reflect the specific behaviour or characteristics envisaged in a particular teaching unit. For example, if one intends to measure the extent to which students are involved in citizenship action relating to environmental issues, direct observation would be the most valid source of information. But, it may not be always feasible to have direct observation evidence due to the wide expanse of environmental action, both in terms of space and time. One may not exactly know where and when environmental action is likely to occur. Even if these two points are located, the process is enormously time consuming and expensive. Naturally, the teacher turns to some other source of evidence to measure this information. He uses self-reporting as a means to this end or else the reporting from others, parents, peers or community members. However, the reporting is to be used with caution to ensure a reasonable level of validity. Situation reaction tests, observation of behaviour in simulated situations, inventories and rating scales can also be used to measure attitudes

Figure 22: Evaluation and Improvement of EE Teaching


EE Curriculum Unit I
Formative Evaluation
EE Curriculum Unit 2
EE Curriculum Unit in Formative Evaluation
EE Objectives
Awareness
Knowledge
Skills
Attitudes
Participation
Teaching Methodologies
Expository
Investigatory problem-solving
Clarifying
Simulation Gaming
Out-of-School Experiences
Measurement
Tests
Inventory/ Scales
Situation Reaction Test
Reporting (Self/others)
Observation
Repeat teaching methodology to unit matching modify
Repeat measurement to unit
Summative Evaluation

and values. Tests, particularly criterion reference tests and teacher-made tests, can be used for evaluating knowledge and awareness of the pupils. So this unit deals with different evaluation modes and tools of evaluation in the context of EE curriculum transactions.

1. Tests: Tests are used to measure the objectives relating to knowledge and awareness. It is not necessary to use norm referenced achievement tests. Criterion reference tests and teacher-made tests will be helpful to measure this domain of objectives. Self-scoring, multiple choice tests can be quite helpful in this context. Framing of questions in these two areas has been extensively illustrated in the Technology of classroom questioning[1]. Test item banks are also available to help the teachers. Sample question is given below:

Smokeless automobiles are needed, because:

(a) it saves fuel costs;

(b) it avoids environmental pollution;

(c) it spoils the engine;

(d) it looks odd.

Situation reaction tests

There are areas of learning, particularly those dealing with reactions, attitudes and values relating to environmental issues and actions which cannot be measured through simple tests. But this area is an important objective in the EE curriculum and teaching. So, situation reaction tests which define the situation and ask for learner reactions considering himself in the situation. The situation reaction tests can be in the form of presentation of the situation and providing alternatives for selecting the one that is nearest to his choice.

Observation in simulated situations

It is not always possible to observe pupils directly in real situations involving environmental issues or actions. So, simulated situations involving environment-related decision-making, issues or actions relating to environment are designed. The pupils perform their roles in the simulated situations, which may be systematically observed and used in evaluation.

Example:

You are appearing before the Commission on Energy Crises Management appointed by the Government. What is the viewpoint you will present before the Commission? You may discuss and formulate your viewpoint.

Observation by pupils and teachers

Self-reporting:

The pupils are required to prepare brief reports on the environmental action or the viewpoints they projected in discussions relating to environmental issues. This may be done periodically. For example, the author of this unit did it once a week.

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[1] N.K. Jangira, Technology of Classroom Questioning, National Publishing House, Darya Ganj, New Delhi, 1983.

On every Monday, students were required to give a write-up on at least one environment-related action. The reporting was semi-structured in the sense that the students were required to keep this frame in mind while preparing the write-up. They were required to note (i) how the situation was defined, (ii) how the viewpoint was expressed or decision taken, (iii) how action was performed, (iv) what the rationale for the decision action was.

Other reporting

In order to support self-reporting, as well as for mutual validation, questionnaires may be formed for reports about students from parents, peers or community members. The questionnaires have to be brief and to the point.

Rating scales

Liking scales, reaction scales, attitude and value scales may be used for measuring effective characteristics.

Systematic observation

Mention was made of observation in the context of simulated situations for evaluation. Systematic observation here is in real situations. Observation notes are kept and collated for drawing references.

The mode of evaluation and the tools for measurement enlisted above are suggestive in the sense that they will have to be specially selected by teachers in situations and according to the objectives. There will always be comparative claims between desirability and feasibility with respect to the validity of measurements. The teacher will have to reconcile the claims keeping in view the situations and available facilities.

8.2 Utilization of evaluation

The results of the measurements are utilized by the teacher for providing feedback to pupils by way of pointing out their strengths and weaknesses. The feedback is provided in a way that their learning behaviour is reinforced and self-concept is improved. It should neither hinder their learning nor lower the self-concept. This particular objective will be achieved, if the teacher also receives feedback - feedback on pupils' learning difficulties, and feedback on the extent to which the teaching methodologies and materials selected had been effective in pupils' learning.

If the feedback is used to modify the teaching behaviour, use alternative teaching procedures and help the pupils in modifying their learning behaviour so as to bridge the gap between the intended behaviour and the observed behaviour. Evaluation data are continuously used for adjusting teaching to the requirements of the pupils, thereby improving the effectiveness of the timekeeping. Finally the data are used to evaluate the EE curriculum, which has already been discussed.

8.3 Try yourself

The EE curriculum follows a multidisciplinary approach. State two implications of this characteristic of the EE curriculum for evaluation in EE.

1. ____________________

2. ____________________

EE has citizenship action as a final goal. State two implications of this objective for evaluation in EE.

1. ____________________

2. ____________________

Give one situation each in EE teaching where the following are used for revaluation.

1. Self reporting ____________________

____

____

2. Other reporting ____________________

____

____

3. Rating scales ____________________

____

4. Situation reaction test ____________________

____

____

1. Situation reaction test as a tool of measurement in EE teaching is useful because it -

(a) is realistic.

(b) is comprehensive.

(c) is an indirect measure.

(d) is economical to assess action.

(tick the correct choice)

2. Observation of pupil behaviour in simulated situation can be used in evaluation in EE teaching when -

(a) direct observation is not feasible.

(b) reporting is doubtful.

(c) tests are not available.

(d) none of the above is applicable.

(tick the correct choice)

3. Rating scales are used for measuring -

(a) the knowledge level of the pupils.

(b) pupil environmental action orientation.

(c) attitude to environmental issues.

(d) decision-making abilities of the pupils.

(tick the correct choice).

UNIT 9

9. CURRICULUM DEVELOPMENT, IMPLEMENTATION AND MANAGEMENT

9.0 Introduction

Curriculum is an instrument to translate educational goals into practice propositions. The development of a functional curriculum, its management and effective implementation go a long way in realizing the educational goals envisaged in a particular curriculum area. What is the conceptual frame for developing EE curricula? How is it to be developed? What is the implementation strategy to be adopted for its implementation? How is it to be evaluated? What is the infrastructural support for its effective management? What are its implications for primary teachers? These questions receive focus in this unit.

OVERVIEW

Objectives

After reading the study sheet 'Curriculum development, implementation and management' and carrying out suggested activities the teachers are expected to realize the following objectives:

1. Describe an infusion model for developing EE curriculum with the help of a properly labelled diagram and operational activities.
2. List the activities in:
    - (a) EE Curriculum Development.
    - (b) EE Curriculum Implementation.
    - (c) EE Curriculum Management.
3. List the variables involved in EE Curriculum Evaluation.
4. List procedures for evaluating an EE curriculum.
5. Describe in about 50 words each at least three procedures for evaluating an EE curriculum listed in (4) above.

Learning activities:

1. Reading of the Study Sheet 'EE Curriculum Development, Implementation and Management'.
2. Carrying out the activities suggested in the study sheet.

Evaluation

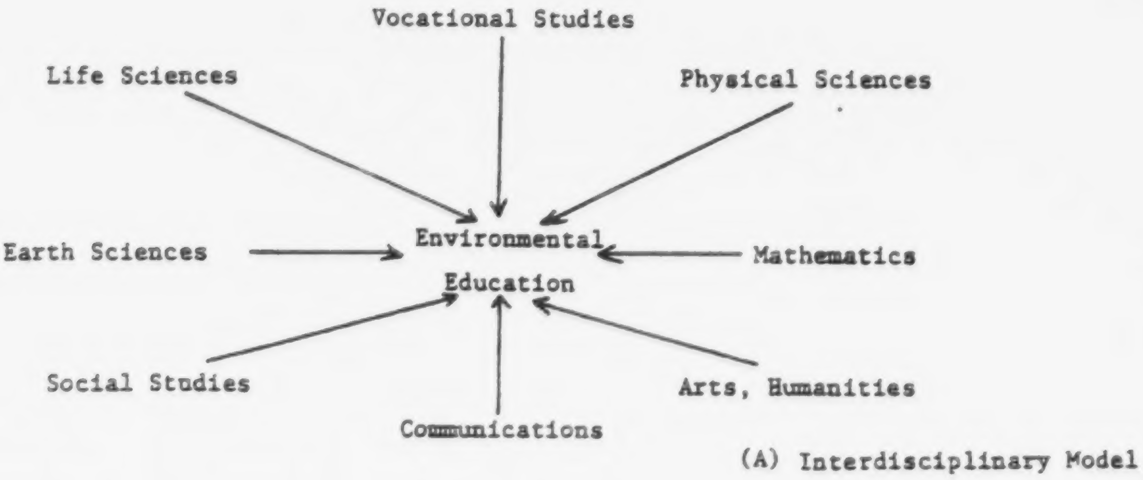
The teachers will be required to answer questions at the end of the unit.

9.1 Curriculum development, implementation and management

9.1.1 Conceptual frame

EE curriculum development is to be preceded by making a decision about the model to be followed. It can be conceived as (a) interdisciplinary which implies that EE is to be considered a separate discipline drawing on other disciplines like science, geography, economics, etc. The incorporation of EE components into other established interrelated disciplines is considered to be multidisciplinary. The latter is also known as an infused model. The model is illustrated in Figure 23.

Interdisciplinary (Single Subject) Model vs the Multidisciplinary (Infused) Model


Vocational Studies
Life Sciences
Physical Sciences
Earth Sciences
Environmental Education
Mathematics
Social Studies
Arts, Humanities
Communications
(A) Interdisciplinary Model

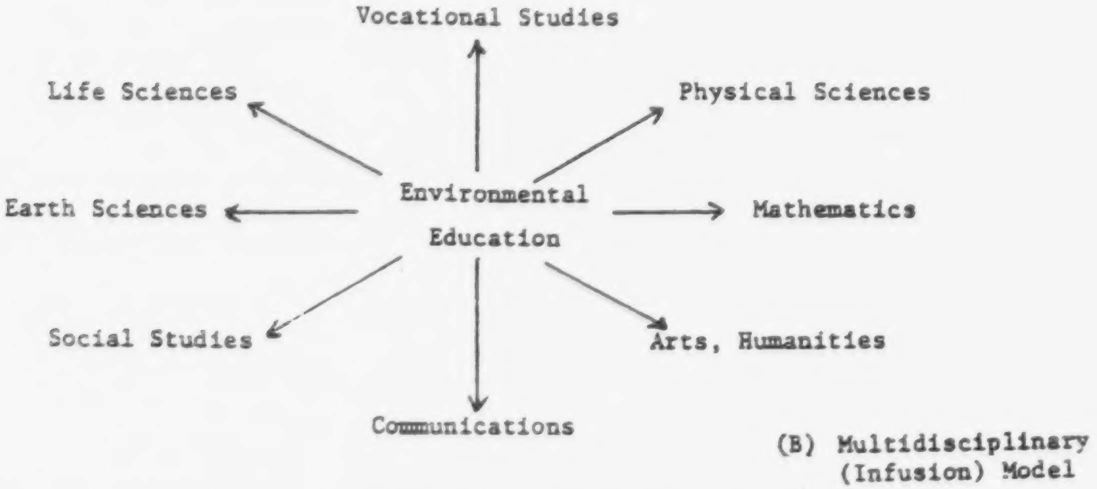

Vocational Studies
Life Sciences
Physical Sciences
Earth Sciences
Environmental Education
Mathematics
Social Studies
Arts, Humanities
Communications
(B) Multidisciplinary (Infusion) Model

Figure 23. Two conceptual models of EE curriculum. In (A) relevant components of many disciplines are drawn upon to create a distinct EE unit, course, or module. (B) illustrates the infusion of EE components into other established disciplines where appropriate.

At the primary level of education an infusion model of EE curriculum appears to be more appropriate as it follows an integrated situational approach. The approach comparatively requires more effort and a little higher level of competence than the interdisciplinary approach. Its strength lies in its making a minimal demand on the existing curriculum load. Moreover, teaching for transfer is inherent in the approach itself. So EE curriculum for the first level of education is to be based on this approach.

9.1.2 Curriculum processes

The curriculum development, implementation and evaluation process constitute an integrated and continuous activity. For the sake of convenience its components can be analysed, isolated and dealt with separately. The integration and continuity of these processes are shown in Figure 24.

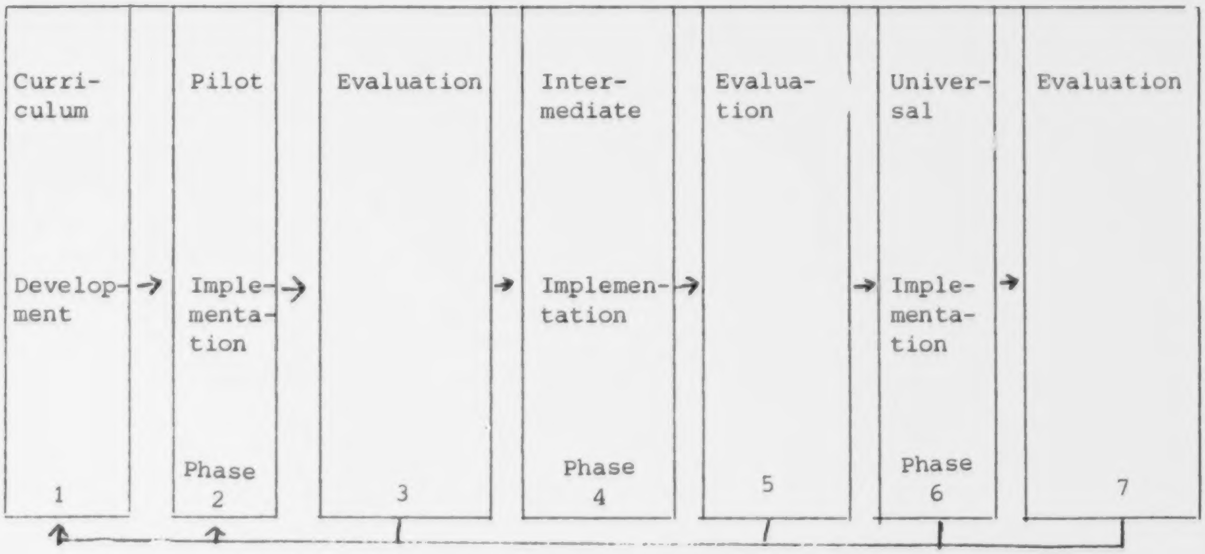


Figure 24. Curriculum development process

The first box indicates the initial curriculum with which the introduction of EE in the school programme is envisaged. The curriculum development activities will be specified a little later in the discussion. The curriculum is then implemented during the pilot implementation phase in a limited number of schools which are evaluated and the results serve as feedback to improve the curriculum as indicated by the arrow in the lower part of the diagram. The modified curriculum is then implemented at the intermediate phase as shown by an arrow joining Boxes 1 and 4 in the upper part of the diagram. This phase is evaluated and feedback is used for further modifying the curriculum as shown by the arrow joining boxes 5 and 1. The remodified curriculum is used for the universal implementation phase in Box 6 which is integrated as well as continuous. The details of the individual activities follow:

9.1.3 EE curriculum development

Curriculum development involves translating EE goals into intermediate and immediate instructional objectives. The goals selected for the EE curriculum need to be assigned to content areas and grade levels. This will determine the scope and sequence of EE curriculum. The three dimensional process of scope and sequence involving content areas, EE goals and grade levels for primary EE curriculum have been conceptualized in Figure 25.

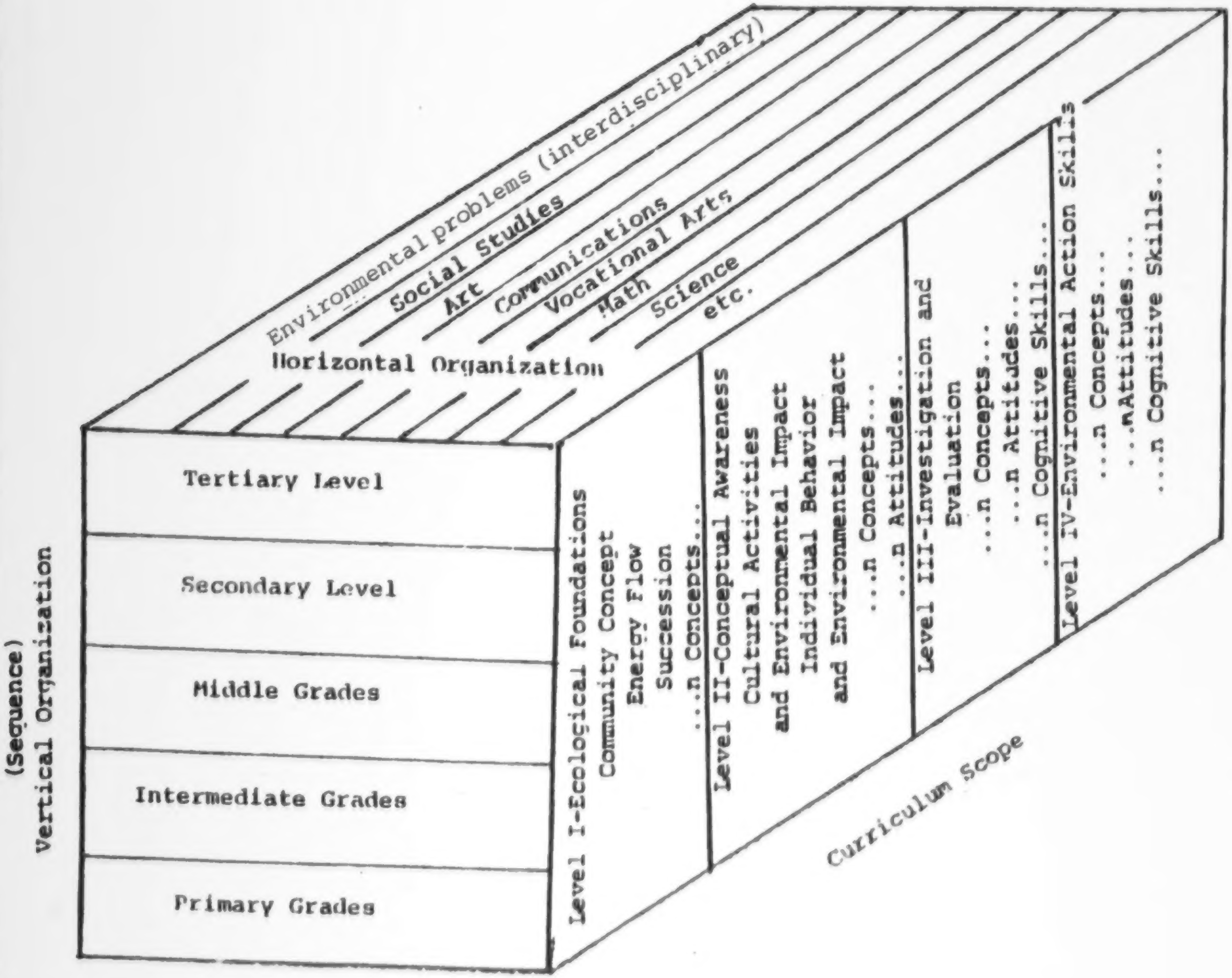

Environmental problems (interdisciplinary)
Social Studies
Art
Communications
Vocational Arts
Math
Science
etc.
Horizontal Organization
Tertiary Level
Secondary Level
Middle Grades
Intermediate Grades
Primary Grades
(Sequence)
Vertical Organization
Level I-Ecological Foundations
Community Concept
Energy Flow
Succession
...n Concepts...
Level II-Conceptual Awareness
Cultural Activities
and Environmental Impact
Individual Behavior
and Environmental Impact
...n Concepts...
...n Attitudes...
Level III-Investigation and
Evaluation
...n Concepts...
...n Attitudes...
...n Cognitive Skills...
Level IV-Environmental Action Skills
...n Concepts...
...nAttitudes...
...n Cognitive Skills...
Curriculum Scope

Figure 25. A conceptual model illustrating the integration of the curriculum scope through grade levels and across subject areas within grade levels.

It will be worthwhile at this stage to examine examples of selected EE objectives at the four levels.

Level I: Ecological Roundation Level

- The pupils will give an example of successional change in the ecosystem.
- The pupils will diagram the energy flow through the community by constructing a food chain.

Level II: Conceptual Awareness Level

The pupils will

- give a definition of the term 'ecosystem'.
- list at least three interactions taking place between human beings and the environment.
- list at least five environmental problems around them.

Level III: Investigation and Evaluation Level

The pupils will

- after reading two news items concerning the environment, state at least two different value positions taken by the authors in the article
- identify at least two environmental issues which need collection of information through a survey.

Level IV: Environmental Action Skills Level

The pupils will

- identify three different modes of persuasion and explain how each can be used towards environmental action.
- identify a given persuasive action as an emotional appeal, logical appeal, coercion, or a combination of these.

The content concerning different objectives has been presented in an earlier unit of this module.

Once the scope and sequence of the EE curriculum is decided, the present curriculum followed in schools is to be analysed with a view to identifying the EE objectives which are already covered in different curricular areas and locating the points of infusion for incorporating the EE objectives not covered in the present curriculum. This is to be followed by the selection of experiences provided by the infusion activities (samples of infusion activities are given in the unit on teaching methodologies). The curriculum materials available and the new ones needed to implement the curriculum are identified. Resources available in the community and school and the professional support needed from the education departure are specified.

This is the task usually performed by the curriculum team entrusted with the preparation of the curriculum. The team comprises curriculum specialists, content specialists, pedagogists and teachers. The curriculum team prepares the EE curriculum plan and the implementation strategy for pilot, intermediate and universal implementation phases along with a plan for a comprehensive evaluation programme.

9.1.4 Curriculum implementation

The EE curriculum implementation is comparatively a more difficult task than its development. The first step in its implementation is its acceptance by the department and the school groups. Besides exposure and persuasive measures, there should be the involvement of persons from all categories associated with the implementation of the EE curriculum at all stages right from policy formulation through curriculum planning and professional mobilization to its evaluation. Secondly, the pilot phase may include the innovating schools amenable to new ideas which can then serve as the focus of the network that can be developed around them over a period of time. Thirdly, the implementation must be preceded by adequate preparation ensuring availability of curriculum material, support for instructional materials, training of personnel, and mobilization of organizational support from the education department.

Two factors are of critical importance in preparation. First, the teacher is to be adequately prepared through a carefully drawn competency based programme of in-service training in implementing the EE curriculum. His training may include basic orientation to ecology: knowledge of environmental issues and problems (covered in the earlier part of this module); field and/or laboratory experiences; competencies in identifying environmental problems; investigation, evaluation and citizenship action; and competencies to use value clarifying strategies.

Secondly, professional support from the supervisory staff by way of adjustment in scheduling and providing committed materials and equipment is indispensable for the success of the programme. Innovations often fail due to the lack of this support.

The curriculum is to be implemented in two to three phases as a matter of strategy. Sometimes, the pilot phase is followed directly by a universal implementation phase while sometimes an intermediate phase is also inserted between the two.

The intermediate phase is usually introduced if the size of the educational organization is quite large. The decision regarding the phasing of EE curriculum implementation depends upon the size of the educational system, infrastructural facilities available and the budget constraints. But the pilot phase should be considered an essential element in the implementation strategy, because it provides the experience and the consequent feedback for its implementation in subsequent stages. Simultaneously, it is helpful in creating a climate for wider implementation through drawing other schools in the area within the network and eliminating their fear of failure with the innovative change.

The primary school teacher's role in implementing the EE curriculum is significant. He should interact with the curriculum team at the time of planning, if he gets such an opportunity. He should co-operate with the local curriculum team entrusted with the task of facilitating EE curriculum implementation. During the in-service training his emphasis should not be only on the materials he is exposed to but he should also adapt them and plan new experiences suited to the ecology of his own school and the environment. He should establish a close link with the EE curriculum consultants and team at different levels. In the school, he will have to plan co-operatively the infusion activities with his colleagues. He will also have to work with the community for not only mobilizing community resources, but also communicating to the community the advantages of the new approach so as to avoid misconceptions arising out of the introduction of this new focus in curriculum. Lastly, he has to constantly evaluate his programme, introspect and discuss with his colleagues, supervisors, and the local curriculum team members for improving its effectiveness.

9.1.5 EE curriculum evaluation

The curriculum evaluation involves several dimensions. The ultimate criterion for the curriculum lies in the pupil's outcomes, the realization of the immediate instructional objectives, which in turn contribute to the realization of EE curricula goals. The pupil's attainments, the indicators of the evaluation of instruction, or the pupil outcomes are discussed independently in the Unit on evaluation. The other aspects of curriculum evaluation refer to concomitant variables - like faculty affect/enthusiasm, pupil affect/enthusiasm, functionality of the curriculum materials, effectiveness of the in-service training of teachers, success of programme co-ordination, effectiveness of supervision from the curriculum team, organizational support available, etc. The information on these aspects can be collected through self-reports from the teachers, students, community members and local supervisors and curriculum team members. Questionnaires can also be designed for the purpose. Interviews can be further revealing. This evaluation is usually carried out by the curriculum professionals and utilized as feedback for curriculum revision and for modifying implementation strategies, wherever necessary.

9.1.6 EE curriculum management

The EE curriculum is essentially an exacting area because of its multidisciplinary nature and recency on the educational scene. The organizational framework for the EE curriculum can be conceptualized along three dimensions: levels of administration (federal, provisional/State, district, subdistrict, institution and the class); interdepartmental linkages (education, environment, science and technology, health, etc.); and functional dimensions (planning, implementation, evaluation, renewal, etc.). At the federal level, the policy on environment and environmental education is formulated. At the State level, the curriculum planning and implementation is taken up; while at the district, subdistrict and institutional levels, executive functions are performed.

There may be a Central Curriculum Development Team (CCDT) comprising teachers, curriculum specialists, content specialists and administrators. The team develops the curriculum.

Curriculum Support Team (CST) at the district and subdistrict levels is constituted for assisting the CCDT in implementing the EE curriculum.

These teams are not only helping the CCDT, they also help the departments of education at district or subdistrict levels to organize in-service programmes for teachers and local supervisors. The teams also provide on-the-spot school based in-service input in implementing the EE curriculum and in evaluating the EE curriculum and related curriculum materials developed by CCDT.

The teachers at the institutional level co-operate with the CST and local supervisors and utilize resources, including supervisory guidance, for effective implementation of the EE curriculum. The CCDT monitors curriculum-related information, processes it and uses it for curriculum renewal and for improving the effectiveness of implementation.

9.2 Check yourself

Below are given questions with four alternative responses. Tick ( ) the one which you consider to be correct.

1. The infusion model of EE is suited at the primary level because it:

   (a) is easier to operate by the teacher;

   (b) keeps curriculum load within reasonable limit;

   (c) is modern in curriculum approaches;

   (d) is liked both by teachers and students.

2. The pilot phase in EE curriculum implementation is essential, because it:

   (a) defines curriculum parameters;

   (b) provides time for making preparations;

   (c) provides experience to the curriculum team;

   (d) makes curriculum implementation easier.

3. Sequence in the EE curriculum means:

   (a) points of infusion in different content areas;

   (b) objectives relating to different content areas;

   (c) placing objectives in order in the EE curriculum for a grade;

   (d) placing objectives in an order in EE curriculum across grades.

4. In EE curriculum evaluation the teacher should help the curriculum support team in:

   (a) analysing the curriculum;

   (b) collecting data from the school;

   (c) writing evaluation reports;

   (d) preparing evaluation tools.

5. EE curriculum development, implementation and evaluation are:

   (a) inseparable parts of the EE curriculum;

   (b) three distinct parts of the EE curriculum;

   (c) inseparable as well as distinct parts of the EE curriculum;

   (d) none of the above.

6. Draw and label diagram illustrating the infusion model of EE curriculum.

7. Define the term 'sequence' in EE curriculum objectives in a sentence.

8. In a country with a large educational system spread over a large geographical area, the EE curriculum should be implemented in the following phases:

   Phase 1. ____

   Phase 2. ____

9. Describe in about 100 words how evaluation can be used to improve the EE curricu curriculum.

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11. GLOSSARY

Abiotic:	Pertaining to non-living factors
Acid rain:	Rainfall which becomes acidic by the absorption of the oxides of nitrogen and sulphur in the air
Ambient air:	Freely circulating air
Anthropogenic:	Man-made, from human sources
Arid:	Extremely dry; barren from lack of moisture
Atmosphere:	The gaseous envelope surrounding the Earth
Autotrophs:	Organisms having the ability to synthesize food from inorganic materials
Bacteria:	Microscopic organisms of various shapes with a simple nucleus and without chlorophyl
Biosphere:	The part of the Earth's crust, water or atmosphere inhabited by living organisms; the sum total of all the ecosystems
Biota:	Animal or plant life of a region or period
Biotic:	Derived from living organisms
Biomes:	The major habitant zones of the Earth with characteristic plant and animal life
Calorie:	A fundamental unit of energy designated by the abbreviation Cal. or C. The quantity of energy as heat required to raise 1 gram of water 1% C under constant pressure of 1 atm.; equal to 1/860 of a watt-hour (see Joule)
Carcinosenic:	Having the property of causing cancer
Carrying capacity:	The maximum population which an environment can support without being degraded in the long run
Community:	A group of organisms living in a common environment
Composting:	The process of letting organic waste (farmyard refuse, domestic garbage) decompose in the presence of air resulting in a nutrient-rich compost or humus
Consumers:	Organisms that depend on other organisms for food
Cosmic:	Pertaining to the part of the material universe especially outside the Earth

Decomposers:	Organisms whose feeding reaction results in the breakdown of large organic molecules of dead organisms into smaller reusable molecules
Demography:	The science of population statistics dealing with birth, death, marriage, etc.
Ecology:	The study of relationships of organisms to one another and the environment
Ecosystem:	A system formed by the interaction of a community of organisms with the environment
Edaphie:	Pertaining to soil
Emigration:	The act of leaving of an individual from a population
Food chain:	A series of organisms, existing in a natural community, through which energy and matter is transferred stepwise in the form of food
Food web:	A complex of food chains involving many different species in a community
General fertility rate:	The number of births per 1,000 women of reproductive age (14-45 years) in the population
General marital fertility rate:	The number of births per 1,000 married women of the reproductive age (14-45 years) in the population
Genetic resource:	All the species in a biosystem serving as repository of genes
Habitat:	The natural environment of an organism
Herbivore:	An animal that feeds on plant material
Heterotrophs:	Organisms that cannot synthesize their own food
Hydrosphere:	The portion of the globe containing water
Immigration:	The act of entering of an individual into a population
Infant mortality rate:	The number of deaths of children under 1 year of age per 1,000 live births in a population
Joule:	The absolute unit of measurement of energy. It is the amount of energy imparted to a body to move it by a force of 1 Newton through a distance of 1 metre. (One Newton is approximately the force required to life a weight of 102 grams) 1 Joule = 1 Watt - second 3.6×10^3 Joules = 1 Watt - hour 1 Calorie = 4.18 Joules

Kcal:	1,000 calorie
Kilowatt:	1,000 Watt
Lithosphere:	Outer solid layer (crust) of the Earth
Malnutrition:	Poor nourishment of the body resulting from an inappropriate (usually deficient) supply of essential nutrients
Maternal mortality rate:	The number of deaths of mothers per thousand births per year
Megawatt:	1,000,000 Watts
Meteorology:	The study of atmospheric phenomena especially of weather and climate
Migration:	Periodic movement of animals from one area to another
Mortality:	Death rate. The number of deaths per 1,000 individuals per year
Natality:	Birth rate. The number of births per 1,000 individuals per year
Niche:	The functional place of an organism in the community or ecosystem
Parasitism:	An association of two organisms in which one is benefited at the expense of the other
Physiography:	The science of physical geography
Plankton:	Organisms that characteristically float on the surface or remain suspended in water
Pollution:	Natural or man-made alteration of air, water and land which become injurious to man, animal, plant or property
Pollutant:	That which pollutes
Population:	A group of individuals of a species living in a particular area
ppm:	Abbreviation of parts per million, used for expressing the concentration of a gas in the air
Potable water:	Water suitable (clean and safe) for drinking
Predation:	A relationship between animals in which one kills and eats the other
Producers:	The green plants which produce food for themselves and for other organisms

Psycho-social:	Pertaining to mind and society
Runoff:	Rain which flows off from land to the seas
Salinity:	Natural or man-made soluble salt contamination of soil, making soil unfit for cultivation
Sewage:	The waste matter which passes through sewer
Sewer:	An artificial conduit, usually underground, for carrying off waste matter and refuge as in a city
Sludge:	Sediment deposited during the treatment of sewage or waste matter
Social forestry:	Development and management of forest through social action, in the common village or community land to meet various community needs
Soil erosion:	Loss of soil resulting from removal by water, wind, glaciers or ocean waves
Sub-surface water:	Water present under the land surface which is distributed in different layers: soil moisture, groundwater within 0.3 km and groundwater deep lying
Symbiosis:	The intimate association between two dissimilar organisms in which both partners derive mutual benefit from each other
Total fertility rate:	The average number of children that would be born alive to each during her total reproductive years
Trophical level:	Each step in a food chain
Watt:	The practical unit of electric power. It represents a rate of expenditure of energy (see Joule and Calorie)